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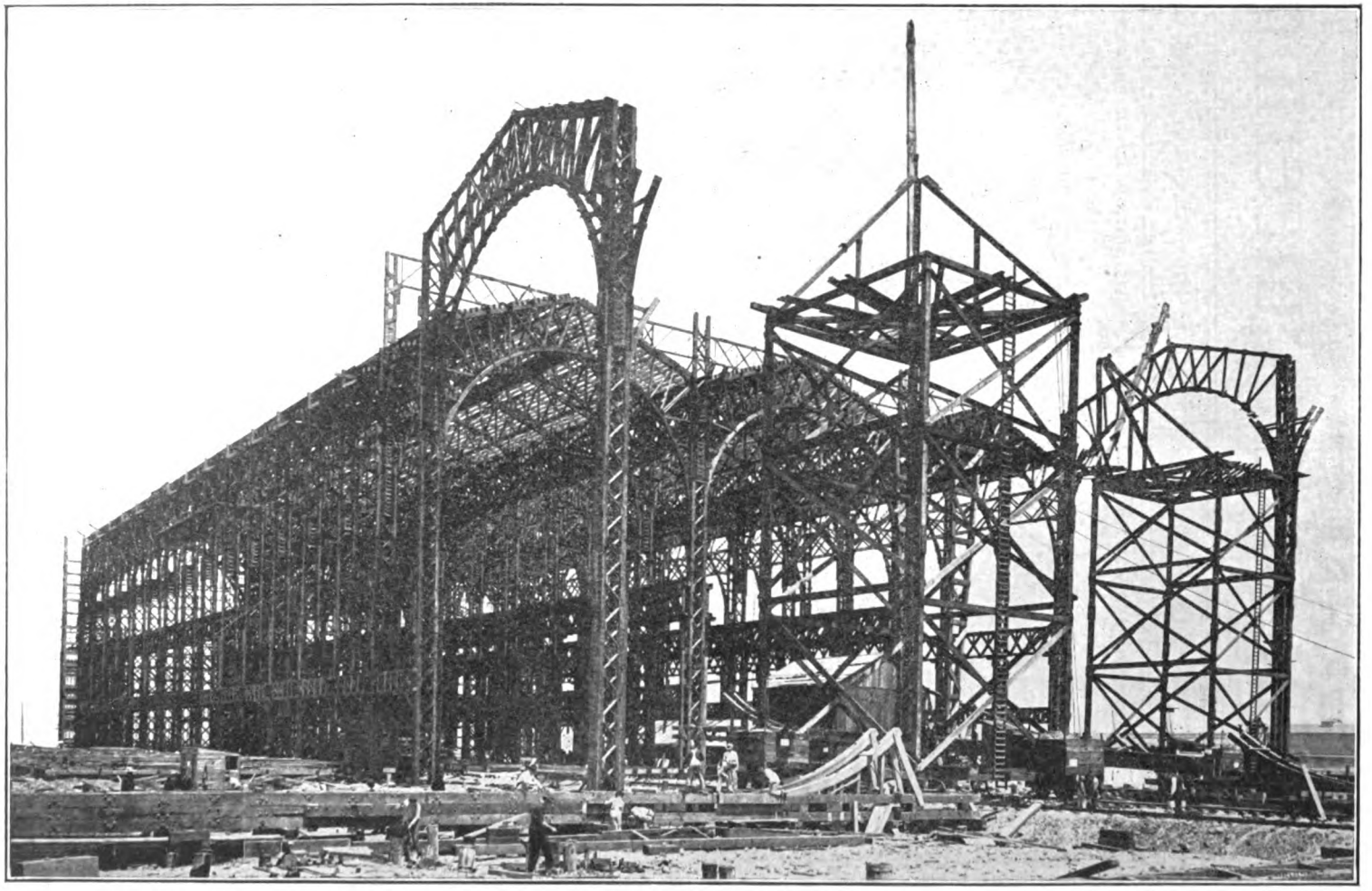

(Photo by F. W. Swadley.) PANAMA-PACIFIC EXPOSITION PALACE FOR MACHINERY, UNDER CONSTRUCTION.

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EDITORIAL

SLIDES in Culebra cut on the Panama canal have emphasized the importance of the part played by steam-shovels in excavation. On Friday, March 28, five steam-shovels removed 10,184 cubic yards, being the largest amount from a single slide in one day since the commencement of canal operations.

EFFICIENCY in every line of endeavor is the best form of provision for the future, and the Efficiency Society Inc. is doing a valuable work by meetings, discussions, and publications, to stimulate greater efficiency in all lines. The first volume of the *Transactions* of the Society recently distributed contains papers covering a wide range of interest, and the *Bulletin* is always full of good things.

JOINT use of track between Wells and Winnemucca by the Southern Pacific and the Western Pacific is now proposed, and the very making of the proposal indicates how far we have traveled from the days when the Western Pacific was first proposed to be built "to prevent the bottling-up of the Gould roads at Ogden by Harriman." The suggestion is a good one, as the two lines will give double track to each system at a minimum cost.

WHAT is announced as the first sale in the United States of a Diesel engine larger than 225 horsepower has been consummated by the New York agent for Usines Carels Fréres of Ghent, Belgium. The order was placed by Phelps, Dodge & Co. for engines to be used in one of their Arizona mining properties, and included two 1000-horsepower, 2-cycle, 4-cylinder Carels Diesel engines. These engines are to be direct connected to 60-cycle alternators to operate in parallel, and are guaranteed to deliver 1000 brake-horsepower at an elevation of 6500 feet with a fuel consumption at full load not to exceed 0.48 pound of oil per brake-horsepower hour.

PROGRESS in constructing the Panama-Pacific Exposition is shown by the view of the Machinery Palace forming the frontispiece for this issue. This building is 368 feet wide and 968 feet long, the floor space being approximately 356,000 square feet. In all, 8,000,000 feet of lumber and 1500 tons of steel are required for its construction. The north and south peaks will be 134 feet high and 120 feet in the clear. The heaviest truss weighs 19 tons and the heaviest column 28 tons. The crew of men employed in its construction numbers 418 in all, including 203 carpenters, 165 laborers, 38 steel and iron workers, 8 pile-drivers, and 4 locomotive engineers.

WATER rights are seriously affected by the decision of the court in the case of the Chandler Dunbar Water Company *v.* the United States. The verdict given by the Michigan federal court for the plaintiff has been reversed by the United States Supreme Court, which held that the Government was not called upon to pay for water-power appurtenant to land condemned

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for the construction of additional locks and canals on St. Mary's river. In making this decision the Court held further that the flow of a navigable stream was in no sense the property of the owner of adjacent land or of the owner of the bed of the river. The decision establishes a precedent that will be far reaching in effect upon both water owners and users.

MANUFACTURE of gasoline from natural gas is exciting increased attention. In the Santa Maria field, the total production of gasoline by this method is estimated at from 4500 to 5000 gallons per day. The Birch property at Fullerton yields 4000 gallons per day. The Pinal-Dome Company is making another addition to its present plant, while the Union Oil Company is building a plant that will have a capacity of approximately 8000 gallons per day, with provision for an addition in the future to double this capacity. When it is taken into consideration that the average extraction is about one gallon of gasoline per 1000 cubic feet of gas, some idea is obtained as to the capacity in gas-compressors required to yield this production.

ANOTHER electrically operated vessel has been launched. In this case it is a canal-boat to ply on Canadian waters for the Montreal Transportation Company. The power equipment includes two direct Diesel-engine-driven generating sets of 300 brake horsepower each at 400 revolutions per minute. The electric generators will furnish power for the operation of screw propellers at 80 revolutions per minute and for operating the usual auxiliaries. The *Tynemouth* is a steel vessel, 250 feet in length, 42 feet 6 inches in width, 19 feet in depth, and carrying a total dead weight of 2400 tons on a mean draft of 14 feet in fresh water. Practically the same method of propulsion is to be used on the United States collier *Jupiter*, now under construction at the Mare Island navy yard, California. Curtis steam turbines are the prime-movers in the latter case, the method of propulsion having been devised by Mr. W. L. R. Emmett, of the General Electric Company.

DESTRUCTION of submerged pipes due to the action of stray electric currents is of frequent occurrence. A few days ago the bursting of a 6-inch water main in the streets of Salt Lake City brought about the fact that the underground pipes throughout a large section of the city are probably in various stages of destruction due to electrolysis. While properly safeguarded electrical construction is undoubtedly the best possible prevention of such occurrences, perfection is seldom if ever attained. The next best solution of the difficulty is frequent inspection of lines to determine whether stray currents exist, and then to remedy the evil at once. Mr. Carl Hering has given an excellent method for the determination and measurement of stray currents in underground pipes, and published in the *Proceedings* of the American Institute of Electrical Engineers for June 1912, and abstracted in the August 1912 issue of *Western Engineering*. Mr. Hering's method will well repay careful study by those interested.

Diesel Engines and Western Oil

Diesel and other types of heavy-oil engines have been exhaustively discussed by engineers and technical periodicals. The gasoline engine has been a sort of 'first aid' to new enterprises

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for many years. The advent of the automobile having sent the price of gasoline skyward, the possibilities of the crude-oil engine for stationary purposes is a topic of more than ordinary interest. Everyone is familiar, more or less, with the results achieved in Europe, but many people have wondered how soon American manufacturers would recognize the possibilities for such engines in the United States. Much unostentatious preparation has been going on, and it will not be long before the Diesel and other types of crude-oil engines will be just as much a staple product on the American market as is the steam turbine, Corliss, or automatic cut-off engine. The Usines Carels Fréres of Ghent, Belgium, has established offices in New York and has already taken an order for a number of Diesel engines for equipping the Phelps-Dodge properties in Arizona. This, we believe, is the plant farthest West at present, and, as these engines will operate on California oil, reports of the results will be awaited with much interest. Arrangements are contemplated for the manufacture of this engine in the United States in order to offer quicker delivery and lower first cost through avoidance of import duty. The New London Ship & Engine Company, of Groton, Connecticut, has been building crude-oil engines for some years, specializing on the marine type. They are equipping submarines for the United States and foreign navies, and are about to install an engine on a merchant vessel now under construction at Seattle. The engines are built under license from the Maschinenfabrik Augsburg-Nürnberg A. G., and afford an instance of the good judgment of American manufacturers in adopting proved practice rather than to indulge in costly experimentation. The Snow Pump Company, of Buffalo, has gone extensively into the manufacture of the Diesel-type engine. Development has proceeded along the lines of European practice, and much experimental work has been conducted with oils and other hydrocarbons from every field in the United States. This engine is of the horizontal type, having the air-compressor an integral part of the engine and direct-driven from the engine crank-shaft. The De la Vergne Machine Company of New York has been manufacturing a crude-oil engine for some time. They do not use the Diesel cycle, the ignition being accomplished by means of a hot ball, enabling the use of a lower compression than that required for the Diesel engine. An instance of the results achieved with this engine is given in the February issue from notes furnished by Mr. W. S. Noyes, of the Presidio Mining Company. The Otto Engine Company is also manufacturing a Diesel-type engine at its Philadelphia works. An engine of its own manufacture is used for generating power for the operation of the shops, and a number of installations have already been made in several of the eastern states. At the works formerly operated by the Atlas Engine Company at Indianapolis, the Lyons-Atlas Diesel Engine Company has been perfecting a Diesel-type engine for many months. Much experimental work has been done with crude oils from the various American fields, including many barrels of the heavy, California, asphaltic-base crude. The Busch-Sulzer Brothers Diesel Engine Company of St. Louis is the pioneer of Diesel engine builders in the United States, having brought what is known as the American Diesel engine to this country some ten years ago. They have recently strengthened their position by

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the acquisition of the right to manufacture the Sulzer Brothers Diesel engine for the United States. A new plant especially designed for the purpose is nearing completion at St. Louis and is expected to be in full operation on September 1 next. This company's experience has been unusually extensive, and this, added to its exceptional equipment, should place it in an excellent position to turn out the high class of work demanded by this type of engine. In San Francisco, the George E. Dow Steam Pumping Engine Company acquired the American rights to the Willans Diesel engine a year ago. Since that time the Diesel engine and pump companies have been consolidated and arrangements have been made to manufacture the Willans engine in the Dow plant at Alameda, California. Another type of crude-oil engine is that manufactured by the Muncie Engine Company of Muncie, Indiana, and Mietz & Weiss of New York. Hot-ball or hot-tube ignition is used with a compression pressure up to about 150 pounds. The fuel consumption is about double that of the Diesel engine, while the first cost is less, due to the lower compression. This type of engine will undoubtedly become popular in the smaller sizes and will find a ready field of application where the engineering requirements are not so rigid as in the larger plants.

This list is not offered as being complete, but is the result of personal observation during a six weeks trip through Eastern manufacturing centres. After discussing with many engineers the subject of the possible application of the Diesel engine to Western conditions of fuel and present power supply, we are of the opinion that the West offers perhaps the best field in the United States for its use. We have no steam coal whatever. Our oil production is phenomenal. Only about 5 per cent of California oil produced is fit for the refinery, therefore we must find a market for our crude. Without going into a long discussion of the comparative merits of steam turbines and Diesel engines, we believe that the large central station plant of tomorrow will be a composite one, each type of prime mover being operated under its own most favorable economic conditions. Paradoxical as it may seem, this should help rather than injure the hydro-electric power companies. The absence of stand-by losses, combined with low operating costs, should be of greatest benefit in stand-by plants, and should help to lower power costs. A lower cost means an increased consumption, and, consequently, increased revenue. It will supplement rather than displace the best present methods of power generation, and will go a long way toward effecting the highest possible efficiency. That a special refined oil is required for the operation of Diesel engines is a mistaken idea, as is also the opinion frequently expressed that oils of asphaltic base are not suitable. It is a question not of the percentage of asphaltum in the oil, but of its flash point and of the efficiency of the oil-atomizing device. The compression must be great enough to attain a temperature sufficiently high to ignite the fuel. Sand and other foreign matter found in crude oil as it comes from the well cannot be burned in a Diesel engine. Such matter should be removed from the oil by some cleansing or filtering process before its use is attempted. We venture to predict that before many months have elapsed the Diesel engine will be operating in the West on California low-grade oil fuel.

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REVIEW OF THE MONTH

SPRING is upon us, and although there is far from a dearth of activity in industrial and engineering circles, yet suspense is the word that best expresses the general situation. One is tempted to wish for the old-school mother to administer copious doses of treacle and sulphur or any other specific that might make men realize that the world is not coming to an end, even though the Democrats are in charge of the ship of state. Uncertainty as to the tariff seems to be the principal cause of unrest, although local disturbances in the way of the usual spring crop of labor troubles are adding their quota to the various ailments that accompany the budding of the roses and the song of the birds.

CENTRAL CALIFORNIA is in the limelight with a strike of linemen and power-plant operators of the Pacific Gas & Electric Company. The usual demands for a shorter workday, half holiday on Saturday, with an increase in pay from $4.25 to $4.75 per day for the linemen, and $10 per month increase in pay for the operators with one day off per week. The company granted many of the demands, but refused to treat with a newly organized general council of all the unions concerned, and particularly objected to a summary ultimatum delivered by this council while negotiations were still in progress. A state of war exists between the two parties, while the third party, the consumer, is, as usual, putting up with inadequate light and heat and in some cases none at all. Some excesses have been committed by the striking linemen, one case of short-circuiting having been reported from Yuba city.

CALIFORNIA is not alone in labor troubles, by any means. A strike among street-car operators resulted in a complete tie-up of all lines in Cincinnati. Rioting in the streets accompanied early attempts to operate the cars with non-union men. Conferences on May 20, however, led to an agreement by both parties to arbitrate their differences, so service has been resumed. As the men have everything to gain and nothing to lose by arbitration, they regard this as a substantial victory.

SALT LAKE CITY is having a strike among the building trades, and operations are effectually tied up at this point. From there the strike is spreading throughout the Northwest and is already on in several cities and towns in Montana and Idaho. The men engaged in the electrical trades are also taking a hand in the fray. Colorado is having troubles of its own through a strike of street-car men at Colorado Springs. An interesting situation lies in the fact that Mr. D. G. Johnson, recently elected Commissioner of Public Safety, was formerly president of the street-car men's union. What Mr. Johnson's course will be in the event of rioting remains to be seen.

PATERSON, New Jersey, is the scene of the most serious strike of the season. The Industrial Workers of

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the World have broken out in a new spot, and while we have the deepest sympathy for the people of Paterson, we are glad of a respite from the activities of this organization in the West, even though it be temporary. Among the names of the 'American' wage-workers who are leaders in the movement, we find Lessig, Treska, Giovanniti, and Rabinovitz. One is tempted to inquire as to the wages and hours obtaining in the various countries from which these workers come and compare them with those against which protest is made. All sorts of trades and occupations are involved, as the strike leaders seem to be industrious talkers, if not especially strong as industrial workers. One of the leaders has been tried and convicted of inciting a riot, and other trials are to follow. The whole situation from east to west reminds us of the small boy who blew up his toy balloon until it burst. There is an elastic limit to the possible inflation of a wage scale, just as there is to a toy balloon. Formerly the corporations had merely to raise rates every time an increase in wages was granted. Now, however, with the various laws in effect regulating public utilities, this is not so simple. The point will soon be reached when an increase in the cost of labor will be destructive to the institution involved, and then what? Public utility corporations in California cannot increase their rates of charge without permission of the Railroad Commission. Will the time come when the trade unions must submit their demands to some impartial body for adjudication? Just now everybody's overdoing it, and there must be an end soon.

IMPROVEMENT of Pacific Coast harbors is being prosecuted with renewed vigor. Colonel Thomas Rees, of the United States Army Engineer Corps, has suggested a comprehensive plan for improving the east shore of San Francisco bay. Nineteen miles of waterfront is included in the project, embracing a territory extending from Oakland through Emeryville, Berkeley, to Richmond and to Alameda. The proposed channel will average 1800 feet in width, and the harbor will be protected against storms and tidal waves. Estimates of cost of the improvements vary from $6,000,000 to $9,000,000, of which a large part has already been pledged or provided by local bond issues. The importance of Colonel Rees' suggestions for coöperative action cannot be overestimated. Self-interest should be subordinated to the good of the community as a whole, and a number of warring factions stand small chance of receiving aid from the federal Government.

ANOTHER effort is to be made to induce the United States to cede Goat island to California. The Legislature has been requested by the Board of Harbor Commissioners to take the matter up, with the view to using the island as a union terminal. Many advantages would accrue to such use. The ferry running-time would be materially reduced, and the concentration of all railroad traffic to and from San Francisco would greatly simplify the handling of passengers.

BUSINESS at Los Angeles' harbor is on the increase, as is shown by the last report of the local branch of the Custom House. The general cargo total has reached the unprecedented figure of 30,096 tons for the month of April, which includes 7428 tons of grain. In all, 241 domestic vessels, with an ag-

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gregate tonnage of 219,201, arrived, and 7 foreign vessels with a total tonnage of 17,530, also reported. When the vast improvements now under way have been completed, Los Angeles will offer excellent facilities for water traffic. The City has asked the War Department to recommend further appropriations for increasing the channel depth from 35 to 40 feet, and also for making a survey to reëstablish harbor lines, primarily to secure the widening of the inner harbor channel mouth from 750 to 1000 feet. Excellent progress is being made by the contractors in the manufacture of the concrete piles for Municipal Pier No. 1. A pile-driver and float are being assembled, and placing the piles will commence in a few days. Fender piles are now being placed on the Mormon island channel wharf, and the entire structure will be ready for service within three weeks.

STATE control of public utilities has been tightened with another rivet in the form of what is known as the Water Commission bill recently passed by the California Legislature. The bill provides in effect that a power company may not capitalize the water rights granted to it by the state. The Railroad Commission is empowered to fix rates for power at a figure that will yield a fair return on the money actually invested. Power companies are required to pay a royalty of 25 cents per horsepower-year for all power hereafter developed, and water rights are to be granted for limited terms instead of in perpetuity. Water for irrigation is also subject to regulation. The doctrine of riparian rights is modified so that hereafter no riparian owner may tie up water flowing past his land, if it can be shown that he does not need it for filling some useful purpose. Failure to put water to a beneficial use for a period of ten years is deemed sufficient proof that the riparian owner does not need it. This feature will, of course, only be effective if approved by the courts, and that is, at least, doubtful. Other provisions include an appropriation of $50,000 for investigation of the water resources of the state, and for the establishment of a water commission consisting of three members at $5000 per year each. The commission will pass upon all applications to appropriate water and will adjust disputed claims. This bill is in line with what has been done elsewhere, both in the United States and abroad. Wisconsin is considering the passage of a similar bill which goes a step farther, in that it provides for the creation of a fund for the recapture by the state of the water rights and all improvements thereon. Of the foreign countries, Norway and New Zealand both have water laws similar to that under consideration at Wisconsin. We doubt that the passage of the California bill will militate against the further development of water for power purposes, although the opponents of the measure are full of gloomy forebodings. The trend of modern political economy is toward the conservation of the national resources of the country for the benefit of the people as a whole, and there is no doubt that similar legislation will soon be enacted in every state where there is any water to conserve.

DURING the early stages of the discussion of the Water Commission bill, it was discovered that its provisions would act with impartial vigor toward the city of Los Angeles in disposing of its water, as well as regulate the most cold-blooded corporation. Of course, this was not to be tolerated for

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a minute, so after much exercise of gray matter, a clause was added exempting municipalities from its provisions, thus providing the exception, without which no rule is complete.

SAN FRANCISCO water-supply affairs, with relation to the negotiations pending between the city officials and the Spring Valley Water Company, have come to life again. A new scheme has been submitted to the city by the Spring Valley company, in brief as follows: The city to purchase the distributing system of the Spring Valley company at once at an appraised valuation. The company to enter into an agreement with the city to furnish water at wholesale at the county line; the city to sell the water to consumers, thus eliminating the question of rates as far as the company is concerned. The company to give the city an option for the purchase of the remainder of its properties at agreed prices for the end, respectively, of five, ten, and fifteen-year periods.

The adoption of this plan would permit the City immediately to add to the pipe-lines, and the Company, on the strength of the agreement with the City, could raise funds for the erection of the Calaveras dam and the construction of another aqueduct from the Alameda county sources to the county line. It is also claimed that the Hetch Hetchy bond issue of $40,000,000, authorized some time ago but not sold, could be disposed of to provide funds for the purchase as recommended.

MOTOR SPIRITS is the name of a new fuel for use in heavy engine work. According to *Oildom*, this fuel is derived from the residue made by a special process of distillation invented and patented by Mr. W. M. Burton of the Standard Oil Company of Indiana. The method used involves the treatment of liquid portions of petroleum having a boiling point in excess of 500°F. to obtain therefrom low boiling-point products of the same series. The process is conducted under a pressure of four or five atmospheres and at temperatures of from 150 to 350° above the boiling point of the liquid, or at 650 to 850°F., and the distillate is then condensed in the usual way. The resultant liquid is described as having a slightly yellowish color, and possessing characteristics as compared to Indiana gasoline as follows:

Product.	Baumé Tests.	Boiling point: Lowest.	Highest.
Motor spirits...	55	95	500
Gasoline	59	110	350

Comparing motor spirits with gasoline, the former has a slightly lower gravity, a higher carbon content, and a higher thermal value, indicating that a higher mileage per gallon can be obtained than with gasoline. The lower initial boiling point shows that starting the motor would be no more difficult than with gasoline. Having about double the range of boiling points, it would be more difficult to vaporize completely, and therefore smoking and carbonization in the cylinders would be greater than with gasoline. These features will probably militate against its use in pleasure vehicles to any great extent, but in commercial vehicles, which use slower-running motors, and where constant operating conditions prevail, these objections will probably be overcome. Motor spirits is sold at a price about three cents less per gallon than gasoline, a reduction of about 16⅔ per cent. This new fuel should help to relieve the shortage in the gasoline supply.

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Hanging Fenders for Docks

By H. J. BRUNNIER*

CONSTRUCTION of harbors or docking places can be classified under three types, quay, docks, and piers. The quay, which consists of bulkheads built along the shore of a bay, channel, or river, the ships lying parallel to the shore line, is used mostly on inland or fresh-water harbors. Docks are formed by dredging slips at angles into the shore, and bulkheading the projecting land. This type of construction is used chiefly in artificially made European ports, where local conditions or restrictions make it the most feasible. The pier type is built from shore out into the water, and is used principally in America. The land in most of our harbors is limited by rapidly rising back-ground, or for various reasons is of such high value that it is economical and almost imperative to build a bulkhead out as far as possible, fill in behind, and build piers outward. The only limitations are the deep water and the U. S. Government regulations. The War Department establishes certain bulkhead lines, beyond which no solid construction will be permitted. But a pier so open as not to interfere with the circulation of water currents and run out to an established pier-head line may be built.

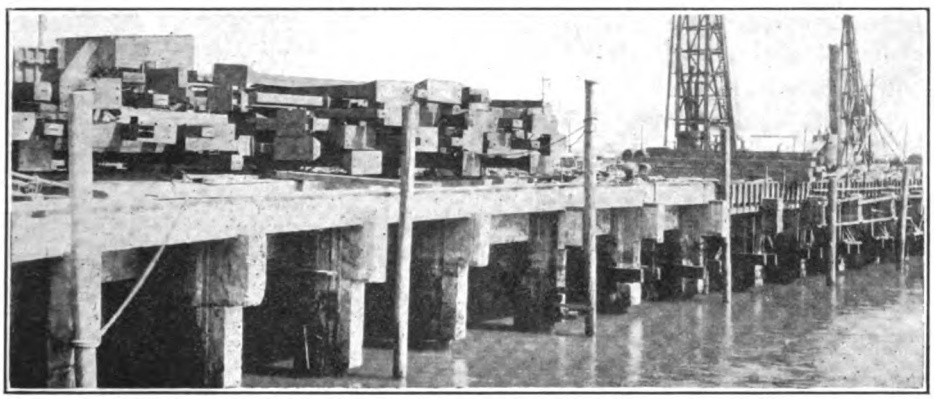

FIG. 1. CONSTRUCTION VIEW OF PIER 26.

Piers are generally built on wood piles unprotected or protected by various methods, on concrete piles, or on concrete or masonry supports run down to hard bottom, or to piles cut off well below the mud-line.

On account of certain destructive wood borers (the teredo, xylotrya, and limnoria being the most common) the green, unprotected or untreated pile

*Consulting Structural Engineer, Sharon Bdg., San Francisco.

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cannot be used in sea water. The teredo and xylotrya, the most ruinous foe to timber used in salt water, are similar in appearance and action. They enter the pile in the form of a minute worm, through a hole no larger than a pin. Once within the wood they begin to bore rapidly, parallel to the grain. One end of the borer remains at the hole through which it enters, the worm growing longer and larger, as it works along. The hole made increases proportionately and is frequently ⅝-in. diameter and 24 to 36 inches in length. They are most aggressive near the mud-line, do not go above the low-water

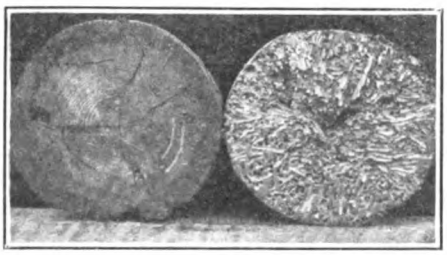

FIG. 2. TEREDO ACTION ON WOOD PILES.

mark, and do not enter above a point several feet below the low-water level.

Fig. 2 shows what has happened to a pile, in an ideal location, attacked for six months. The borers generally destroy a pile in from six months to two years, depending on conditions. As their workings are not apparent on the outside of a timber, a pile may be completely ruined and yet not be discovered until after a failure.

The limnoria or 'wood louse' is about the size of a grain of rice, and works at the surface of the water between high and low-tide level, and makes its attack on the outside of the timber. It does not enter or live inside. As a result, when a pile has been exposed for a sufficient length of time, it has the appearance, between high and low water, of an hourglass, the narrowest portion being at mean tide level. The limnoria does not ruin timber nearly as fast as the teredo, and its attack destroys about ¼-in. thickness of sur-

FIG. 3. LIMNORIA ACTION ON WOOD PILES.

face per year. Fig. 3 shows the action of limnoria after three years exposure in San Francisco harbor.[1]

With the construction of piers, fenders were found necessary on account of cross-currents carrying vessels sidewise and driving them against the side

[1]For a more specific and scientific treatise on these marine wood-borers, see Charles H. Snow's article in the 1898 year book, *Proceedings* of the American Society of Civil Engineers, Vol. XL, p. 178; also the U. S. Forest Service publications. Under the supervision of C. Stowell Smith, the Government is making some elaborate and interesting tests on the Pacific Coast.

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of the berth. These bumpers were generally made by driving piles alongside and were framed in various ways to take up the shock.

In San Francisco, the fender line has, in the past, been constructed as shown in the left-hand view of Fig. 1. The fenders consist of first-quality, fresh-cut Douglas yellow fir pines, measuring not less than 16 in. at the butt, driven in a line about 3 ft. on centres and tied together near the top by two tiers of ribbing. Each tier is fastened to every pile by 1⅛-in. screw bolts countersunk 2 in. into the pile. The upper line of ribbing is composed of three pieces of 4 by 16-in. timber, and the lower one of three pieces 6 by 12 in. All timber is surfaced to uniform thickness and width, and thoroughly spiked together. At the lower tier of ribbing, a line of 10 by 12-in. chocks are placed between and let 2 in. into all piles. Between the upper tier of ribbing and the outer beam of pier framing, a triple-coil car-spring is placed about 10 to 15 ft. centres. The spacing depends on the construction and the spacing of the supporting-bents of the wharf. The spring is held in place by a 1½-in. bolt which slides in a sleeve through the beam. This bolt also prevents the fender line from pulling away from the pier.

This type costs from $7 to $10 per lineal foot of fender line, depending on the depth and kind of material into which the piles have to be driven. Green piles are used because it has been found that the treated fender pile will not give the additional service to warrant the initial expense; also because the creosote leaches out. The timber is weakened structurally and made more brittle by the treatment process, and also the chafing of vessels alongside wears off the protection and allows the enemy to enter.

In recent years, the principal new piers built in sea-water are of permanent construction, concrete and steel throughout, but still using the old type of fender with its expensive repairs.

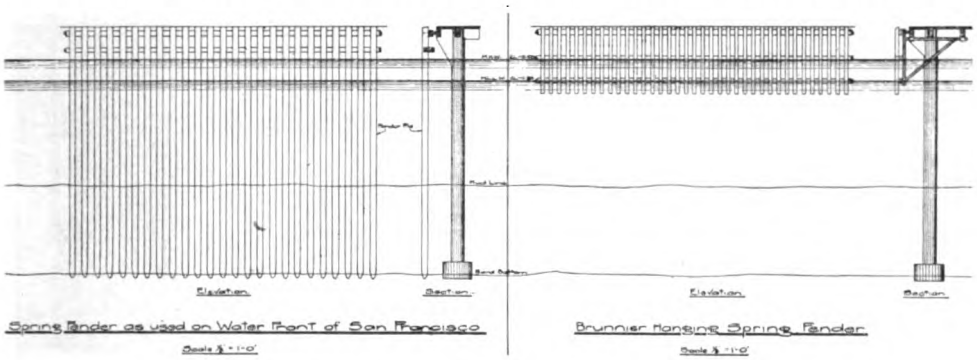

FIG. 4.

The hanging fender[2] can be built in various ways to suit different conditions. Fig. 5 shows a type of hanging fender which can be attached to any pier already built and on which no special provision has been made for its use. It consists chiefly of a steel carrying-frame built up of 'H' column sections, supported from the pier by means of cast-iron guides thoroughly bolted to the decking. Care must be taken to have the inclined 'H'-strut greater than 45° with the vertical so as to make its resultant horizontal force the greater.

[2]Patented by H. J. Brunnier.

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There are three tiers of ribbing fastened to the vertical steel. The size of these should vary for different conditions of water currents and also depending on the types of vessels likely to dock. In general, the lower two tiers should be made up of three pieces of 4 by 12-in. timber, and the upper one of three pieces of 4 by 16 in. To these ribbings should be fastened vertical 10 by 10-in. sheathing with 1-in. bolts, spaced about two to three feet centres and run down at least three feet below low water. In between those on the middle tier of ribbing should be bolted a line of 10

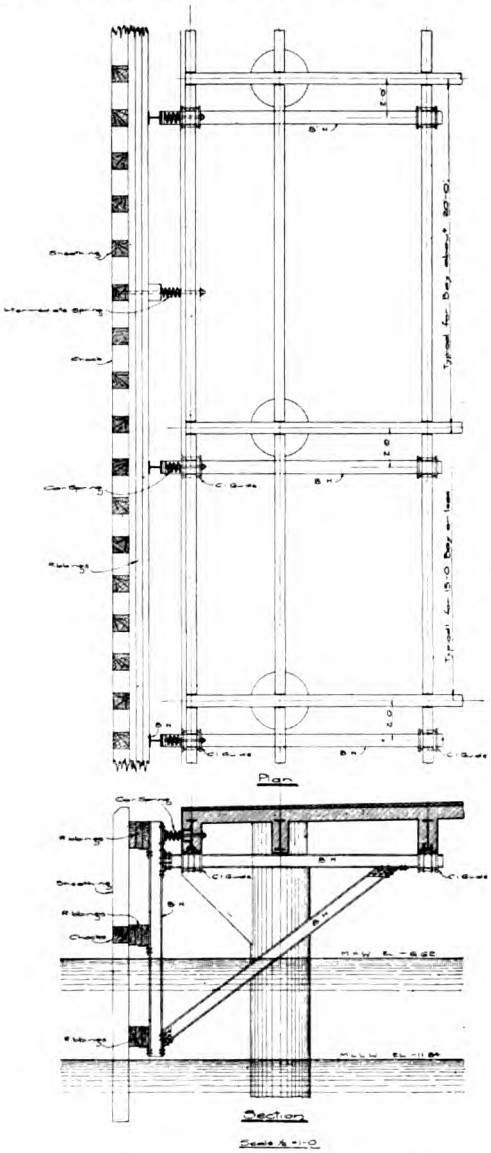

FIG. 5. A TYPE OF HANGING FENDER.

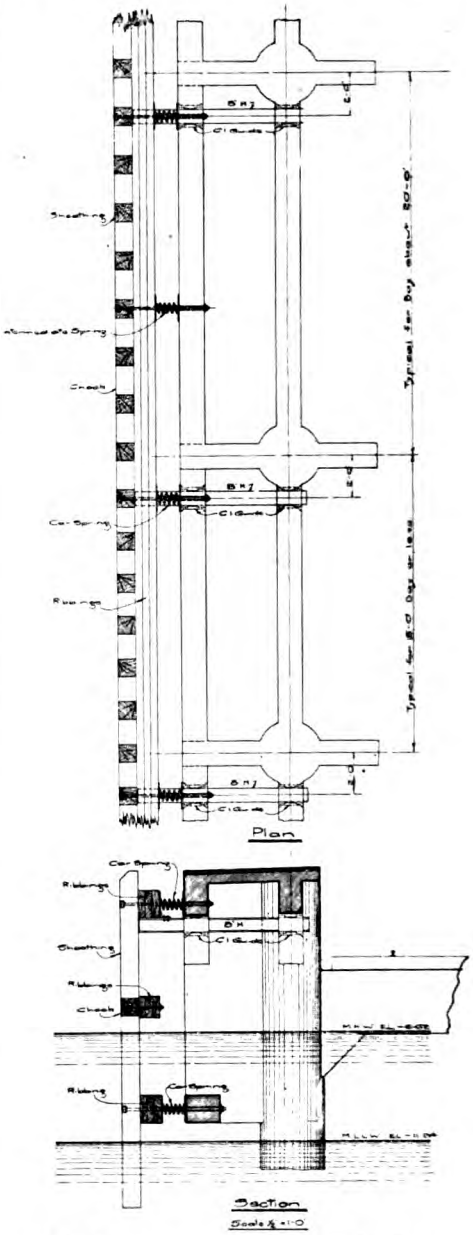

FIG. 6. A TYPE OF HANGING FENDER.

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by 10-in. chocks. This prevents the verticals from twisting. All lumber should be surfaced to uniform size and thoroughly bolted and spiked together. Between the upper tier of ribbing and the outer beam of the pier-framing should be placed a triple-coil car-spring or any other equally resilient device, with a 1½-in. bolt through the spring free to slide through a sleeve in the floor. This type costs from $14 to $18 per lineal foot in place, depending on the pier construction and range of tide.

Fig. 6 shows a sliding hanging fender supported by a heavy 'H'-column section which is supported by and slides through cast-iron guides anchored into the concrete construction. This type requires a cantilever projection at each bent, and recesses for springs and supporting-beam. Or, if it is desirable to frame off centre of bents with the springs and beam, an additional beam would be required at the bottom as shown. The timber framing is similar to that previously described except that both the upper and lower ribbing are heavy and that all are carried by the upper tier. Its principal advantage is that in case of accident it gives a vessel the greatest distance to pass through after first resistance before the boat can come in contact with the solid construction.

Fig. 7 shows in detaill the hanging fender as it is to be on piers 26, 28, 30, 32, 37, and 39, for the city of San Francisco, which are now in course of construction, and is similar to that shown in Fig. 6 except that the cantilever-arm projects out a little farther and has a steel wearing surface upon which the upper tier of ribbing rests and slides. The upper tier carries the balance of the framing as in the other detail. Fig. 1 is a constructional view of pier 26, showing the method of framing and also the stripped concrete of the cantilever.

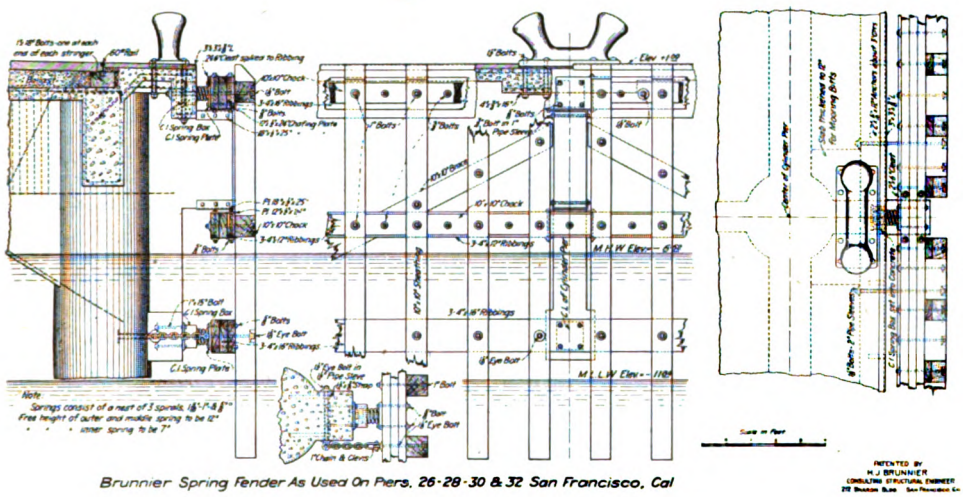

FIG. 7.

Having in mind the destructiveness of the teredo, xylotrya, and the rest of the species, the great saving effected by the use of the hanging fender will be apparent at once. This saving is not alone in material and cost of re-

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pairs, but also in dock facilities. When a pile-driver and crew are repairing the pile fender-line, a vessel cannot lie alongside, while with a hanging fender, if for any reason it needs repairs, the traffic can go on uninterrupted.

Construction of Irrigation Canal Systems From an Operation Standpoint

By P. M. FOGG*

THE operation and maintenance of a large irrigation project discloses the importance of certain features of the canal and distributary systems which are apt to be considered of minor significance or are accorded little or no attention by the construction engineers at the time the project is built. The lack of attention to such details during the construction period when matters of greater magnitude naturally demand and receive primary consideration is likely to react later upon the operation force as a serious handicap and may possibly render necessary the expenditure of a considerable amount of the maintenance funds which expense could otherwise have been avoided. Theoretical formulas should be tempered with a practical knowledge of the actual working requirements for successful irrigation; otherwise what might appear as most efficient and economical construction from both the standpoint of immediate outlay and that of low maintenance cost, may prove to be lacking in the essential characteristics which would render it satisfactory for operation. Certain of such general features deserving of careful attention during the construction of the project are briefly discussed in the following paragraphs.

Topographic Data.—In order to make a thoroughly satisfactory study of the proposed canal and lateral systems, location of structures and the future requirements for drainage, the topography of the tract should be mapped on a convenient scale, say 1000 ft. to the inch, and every effort should be made to secure accuracy in this work. The topographic sheets will be found to be of inestimable value in solving operation difficulties, and inaccurate topography is almost worse than none. If the tract is rough or rolling and lacking in general slope, 5-ft. contour intervals are not sufficiently close; 2-ft. contour intervals are much more satisfactory and will preclude subsequent expense in securing additional local field data from time to time. All of the work should be based on a thoroughly checked system of levels, supported by stable bench-marks properly stamped.

Design and Location of Canals.—In the design of the sections for the canals, careful study of the nature of the soils will be amply justified. The selection of an unnecessarily high value for n in Kutter's formula for velocities may result in the useless expenditure of thousands of dollars for the excavation of over-large sections.

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This could be avoided by giving this matter a careful investigation, which is too frequently not done. Having in mind the duty of water for the type of soil to be served, the canal section should, under ordinary conditions, be varied in the course of the waterway to secure at any point approximately the capacity required for the remaining area of land to be watered. It is well, however, to construct the lower end of sufficient size to carry an emergency discharge to the waste channel. Wide, shallow sections are conducive to greater seepage and evaporation losses than deeper, narrower sections, although in sandy soils the former are less expensive to maintain. The maximum velocity of flow is a very important matter from the maintenance standpoint. Canals without bottom slope, even though short, are difficult to operate, and owing to the lack of velocity, more readily acquire aquatic growths, and should be avoided. Excessive slope, on the other hand, creates velocities which are likely to erode the banks more or less, deposit soil at the curves, and necessitate the riprapping, cleaning, and strengthening work, which increases the upkeep expense. The practice of designing a canal in such a way that a body of dead water is carried at the bottom of the section, too low to be diverted to the land, is also to be avoided.

Where conditions appear favorable, and the surface slopes well, there is a natural tendency on the part of locating engineers to establish the main canals in economic cut. From a construction standpoint this may be admirable, but unless there is a very decided slope to the ground-surface, it is likely to result in leaving a strip of land immediately adjacent to the lower side of the canal, which is either above the normal water surface or at so nearly the same elevation that unless the water is at all times carried at normal height, the strip is not irrigable, and remains a constant source of irritation to all concerned. Care should therefore be exercised in such cases to locate the canal in such a way as to keep the water surface well above the adjacent land, except on side-hill construction, where the waterway should be carried in heavier cut in order to afford an ample lower bank and sufficient freeboard. A greater freeboard at fills and on side-hill locations will assist in protecting the canal from overflow breaks at those points.

All important canals should be provided with ample waste-ways at intervals of 6 to 8 miles, to permit of easier adjustments of flow and for use in emergencies. Drainage culverts of adequate size and permanent materials should be provided beneath the canals at points where seepage or flood-waters will be likely to gather.

Distribution System. — The smaller laterals, carrying 30 second-feet or less, will, if topography permit, present a better appearance and afford better satisfaction from an operation viewpoint if situated along property lines; they are easier to patrol when so situated, and do not arbitrarily divide the farm units into irregular tracts. They also require fewer structures for operation. The laterals should, where feasible, be so constructed that the bottom grade at the headgate corresponds with that of the supply canal, thus drawing off the silt deposits. The water surface in the lateral should be held at least six inches to a foot higher than the adjacent land to be irrigated; this allows for losses of head in measuring over weirs, for transmission losses in farm ditches, and also affords an irrigation head for the farmer's use.

The principles regarding velocity and

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slopes as applied to canals are also applicable to the smaller laterals. It is well to bear in mind that the lateral system should preferably be so designed as ultimately to permit of a rotation system of delivery, and except in special cases, a minimum capacity of 5 or 6 second-feet is desirable at the lower ends. The rotation form of delivery will be based either upon a constant flow in the laterals with rotation among groups of farmers on each ditch, or else upon the idea of supplying water for limited periods to each lateral, in which case the capacity required will necessarily be much greater than in the first case, in order to supply a large head to each farm. Local conditions will govern decisions of this character; in certain sections of the West it is desirable to run a continuous stream in the distributary system during the irrigation season to prevent the checking and cracking of the soil in the laterals. It is preferable, in any event, that the small ditches be given too large rather than too small capacity, as the small areas rapidly clog with soil and weeds and require early maintenance expense. Curves can readily be 'run in' by eye in the location work, thus saving the time which inexperienced party chiefs would use in staking out curves by formulas.

Structures.—For permanence, tap-boxes diverting water from main canals into laterals should be built of concrete or other durable material, especially where sandy soils predominate, as a few years' use of timber boxes in such cases requires replacement and consequent heavy maintenance expense. For the same reason, checks, drops, and other permanent structures in the canal system should be of lasting construction. Checks should be so designed that the net width of opening is slightly in excess of the mean width of the maximum water-section of the canal. This permits the water to enter and leave the structure quietly, and assists in preventing erosion of the canal banks. It is well to design the structure so as to operate it with either underflow or overflow. This feature is especially desirable in small laterals. The designing engineer should also bear in mind that a structure intended to check the flow will materially decrease the capacity of the waterway above the check by lowering the velocity; a fact which is very noticeable in the smaller ditches. It is essential that all structures which permit of any regulation be provided with means for locking, so that only authorized persons may alter the position of the movable parts.

Notch drops are effective for falls, when properly designed, and the use of chutes is attended with less expense in some cases than a series of drops. Small laterals lined with heavy brush, securely laid into the banks, will carry water on a steep slope without erosion, thus combining the advantages of low first cost with the minimum of expense for upkeep.

It is believed that by bearing in mind details of the above nature, and matters of a similar character, the constructing engineer may more readily adjust the plans for the irrigation system so that the work of the operating force which follows may be rendered more efficient and economical. Too frequently the construction work is pushed ahead with an eye single to low first cost, with the inevitable result of a high maintenance cost a few years later. Such a course may be approved among the circles which promote flimsy and unstable projects, but it is poor economy in the long run.

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A Method of Cementing-Off Water in Drilling Wells

By PAUL M. PAINE*

THE serious nature of the water problem in the developed oil-fields of the state is beginning to receive the attention it warrants. It is generally conceded that to strike at the root of the problem is to shut off the water effectually in the first instance by the use of cement at the time the well is drilled and before the final string of pipe has been carried into the oil-sand. The following method for cementing has been developed because it was felt that the older methods of placing the cement, by use of a bailer or pumping it in with the various forms of packers, failed to insure that it would get up on the outside of the casing sufficiently far to prove of permanent value. In modified forms, it is now used by many of the operating companies and independent cementers. Briefly, it consists in pumping the cement to the bottom of the hole through a string of tubing under conditions that force the greater portion of the cement to travel upward between the outside of the casing and the wall of the hole.

After the hole has been drilled to the desired depth and reamed, a pump of the 10 by 5 by 12-in. type used for pumping mud at the rotary wells is installed, and a circulation obtained with water; namely, the water is pumped down inside the casing and caused to come to the surface on the outside. The casing is then held with its shoe about 6 or 8 ft. from the bottom and a string of tubing is run in till its bottom is slightly above the casing shoe. As seen by the figure, the packing-head and gland around the tubing closes off the top of the casing. Therefore when the casing is full of water, and the cement is pumped in through the tubing, it follows the path of least resistance and moves up on the outside of the casing. For this reason it is imperative that the circulation on the outside of the casing be obtained before pumping in the cement. On the bottom joint of tubing has been placed a 2½ by 2-in. bushing. After the cement tank has been drained, a wood plug that will just travel inside the 2½-in. tubing is dropped in through the tee at the top, and water is then pumped in, pushing the plug and cement ahead of it. The cement is known to be out of the tubing when the plug is stopped by the bushing, causing the pressure to go up on a gauge at the pump. The casing is then lowered to the bottom of the hole and the tubing pulled out as rapidly as possible in order that the bailer may get out what cement remains inside the pipe before it has had time to set. The cement is then allowed from 10 to 30 days in which to set, after which the well is drilled a few feet ahead of the bottom of the casing and then bailed dry. If no water comes in during the next 24 hours, it is assumed that the job is good and drilling operations are resumed.

Where 2½ tons of cement had been

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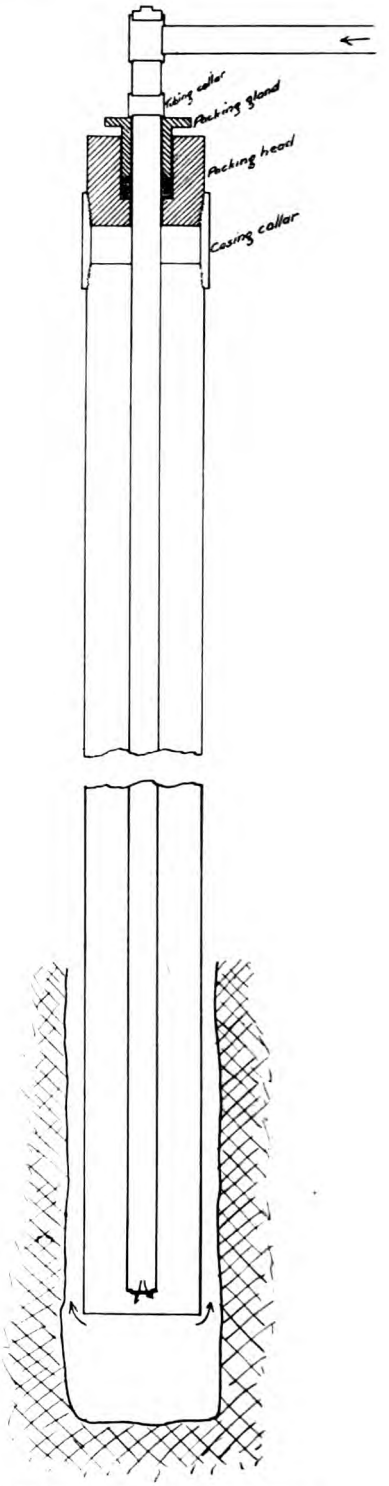
used by this method to shut off water back of a string of 8¼-in. 28-lb. casing, it was found that the cement had set for a distance of 65 ft. up from the bottom. In this well, a still lower water-sand was encountered, requiring that the casing be cut off 200 ft. from bottom and the well re-drilled from that point with a new hole beside the original pipe.

In the preliminary operation of securing a circulation, the pump will, in some wells, work easily even though the water does not come up to the surface, due to the water running off in a loose, porous material. It is often advisable, in this case, to pump in mud until the walls of the stratum have been 'mudded up' and a circulation to the surface obtained. That the circulation is about the bottom of the pipe and not through leaks in the casing due to defective welds may be determined by lowering the casing to the bottom of the well while continuing to pump. If the water is coming through a leak, the circulation will continue; if the circulation has been entirely around the bottom of the pipe, the pressure will stop the pump. Before running in the tubing, the wooden plug should be dropped through each joint, to make sure that no blisters or irregularities will stop it. For the same reason, any tubing nipples that have been cut with pipe cutters should be carefully reamed. The quantity of cement used and its consistence when pumped in, vary with the individual ideas of the users, from 2 to 6 tons dry weight being customary.

It would be of great value to know the influence of the gypsum in cement, that is put in to retard normal setting, on the rate of setting under the different underground conditions of pressure, alkalinity, and presence of gas and oil.



ARRANGEMENT FOR CEMENTING.

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Elements in Oil-Well Drilling

By DORSEY HAGER*

WHEN a site has been selected it is necessary to choose the proper kind of rig for testing. Portable rigs, or permanent rigs, may be used as desired. If it is required to drill a series of holes from 300 to 1000 ft. deep, a portable rig capable of drilling 1200 or 1500 ft. may be employed for this purpose. Such rigs are capable of excellent work up to 1000 ft., but when it is necessary to carry a heavy string of casing, portable outfits become undesirable. Their use, however, is very desirable in regions where the formations require little or no casing to keep the drill-holes in shape. However, when it becomes necessary to handle several 'strings' of casing, permanent rigs are much more desirable than portable.

The portability of a rig is only one feature, and has to do chiefly with convenience of moving a drilling machine. We must now consider the selection of a drilling system best adapted to meet local geological conditions.

There are three principal drilling systems employed in oilfield work:

A—Standard cable-tool system.

B—Hydraulic rotary system.

C—A combination of A and B.

The choice of one of these systems depends principally upon geological factors. A discussion of these factors, and their effect upon the drilling of holes, gives a key to the selection of the rig. As nearly all engineers are familiar with the various drilling systems, descriptions of the same will not be given here.

The standard cable-tool system is perhaps the most generally used, and the most popular system in use at the present time. An addition, or rather an improvement to this system, consists in what is called the 'circulator' method. In this method, standard cable tools are employed while water is caused to circulate through a casing as with the hydraulic rotary system.

In drilling an oil well the chief aims are:

1. To find commercially valuable deposits.

2. To drill a hole of correct size for obtaining and maintaining a good production.

3. To drill in as short a time as possible.

4. To exclude all water from the oil sands.

Thus we have four distinct aims in view. Locating concerns the probabilities of finding oil. As this is a subject by itself, I will not go into this question here.

It is generally considered desirable to finish a hole with a casing diameter not under 4½ in., better sizes being 6⅝ to 8¼ in. To obtain a 400-ft. hole with a diameter of 6¼ in., the engineer would proceed as follows:

To allow for probable water sands, trouble with the upper casing, and accidents, it is advisable to start with the top diameter 10 in. This permits the

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use of 8¼-in. casing inside the 10 in., 6¼ in. inside the 8¼ in., and then 4½ in. inside the 6⅝ in. In many cases it will be possible to finish a hole of this depth with two strings of casing, 10 and 8¼-in. sizes. The two extra sizes, 6⅝ and 4½ in., allow for unusual trouble.

A standard cable tool hole 2500 ft. in depth would be started with 16-in. or even 18-in. casing. This would allow a 12½-in. inside the 16-in., 10-in. inside the 12½-in., 8¼-in. inside the 10-in., 6⅝ in. inside the 8¼-in., and 4½-in. inside the 6⅝-in. Even then, 3-in. casing might be used inside the 4½-in. Such an unusual amount of casing is hardly ever used. Holes are generally finished with 8¼ or 6⅝-in. sizes when starting with the 16-in. size at the top. The casing noted above is required in a standard cable system of drilling. In rotary drilling the two holes described above would be finished as follows: The 400-ft. hole would have two strings of casing; one 10 in. diameter, the other 8¼ in.; 2500-ft. holes would be finished with two 'strings' of casing, one 12½ in. diameter, the other 8¼ in., or even 10 in., though in some unusual cases three or four 'strings' might be required.

The principal factors influencing the above selections of casing are water sands and quicksands. In both systems of drilling it is necessary to make sure that all water is kept from entering the oil sand from any formations lying above the sand. In some cases, prospecting below a proved oil-sand shows a lower water-sand, and then below that a second oil-sand, as is sometimes the case. It then becomes desirable, though not absolutely necessary, to use an extra string of casing to shut off water.

In rotary drilling, the drill-hole is kept full of water circulating continually. Quicksands are easily penetrated by this method, as the head of water in the hole keeps the sand from coming in too freely. With standard cable tools, however, quicksands, or loose friable sands of any kind become a source of trouble and require 'casing off.' Where quicksands are present, the standard hole would require at least one more string of casing than by using the rotary system. However, where the 'circulator' method is employed, the rotary system has no advantage over the standard tools in regard to amount of casing.

Water-sands and quicksands must be considered in another light. Even when they do not affect drilling, they may later, when under considerable head, collapse the casing and destroy the hole. This becomes a distinct evil and causes a great deal of extra trouble and expense. To overcome these pressures, extra heavy casing must be used.

I have now considered the principal requirements of casing as affected by geological factors. Discussion of the above requirements apply where drilling is carried on in soft formations. Where limestones or sandstones are the predominant features, there is little need for casing except for water-bearing formations.

Another requirement for favorable holes is that they be straight. Crooked holes cause unnecessary expense, and later cause great wear and tear in the producing well. Sometimes crooked holes seriously interfere with the entrance of casing. This results in loss of time and sometimes loss of part of the casing. The principal cause of crooked holes is the striking of hard strata that have rather steep dips. Suppose we are drilling in shale or clay and the drill suddenly strikes a hard

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strata of sandstone which deflects it from its course. If the drill is allowed to feed too rapidly, it will follow down the hard strata until the drill-stem strikes the opposite wall of the hole. The longer the drill-stem, the less the deflection. If drilling proceeds slowly, a straight hole will result without much extra trouble or loss of time.

With the rotary system, the deflection of the drill is limited by the elasticity of the drill-pipe. When the drill is bent to strike the opposite wall, it will proceed through the hard formation. Slow, careful drilling will in this case give a straight hole. When drilling where the dips are known to be steep, it is a wise precaution to proceed slowly when a hard formation is encountered. Knowledge of such formation is quickly ascertained by any competent driller who has instinctively learned to recognize the difference of formations by the way in which the blow of the drill is transmitted through the drilling line. A good driller can often tell immediately when the drilling bit has encountered a hard formation by the sound of his tools, and will modify procedure to correspond.

Concrete Slab Flume Construction—Part II

By S. L. STOVALL*

The yard was large enough to store about 400 slabs and still have room enough in which to go on with the manufacture. Since the slabs had to remain on platforms for five days, about 100 of these platforms were provided. Collars were taken off at the end of 24 hours. At the end of four or five days the slabs were edged and left for two or two and a half weeks longer. In hot dry weather they were covered with heavy burlap and kept wet for ten days. Slabs were ready to take out of the yard in almost any kind of weather at the end of 21 days. It was planned to make an average of 20 slabs per day. The average day's work during the manufacturing of some 2500 slabs was less than 10, this low average being due principally to the fact that the cured concrete slabs were not hauled away.

A mix of 1:3:6 was used, and this required an average of 3.6 sacks of cement per measured cubic yard of concrete. One pound of alum per sack of cement was used for water-proofing. The material was mixed in a gasoline-driven Ransome concrete mixer and hauled to the forms in Ransome concrete buggies. The mixer was provided with a loading hopper mounted on trucks and moved under its own power. It was later used along the bottom of the main conduit line in mixing concrete.

This design offers good facilities for testing. Small slabs, duplicates of the slabs used in bench construction, were made 1 ft. long and a bottom put in just as in the bench construction. The slabs were all tested by means of a rope attached at one end to the slabs and passing over a pulley suspended from a tripod. A weight at the other end of the rope completed the testing apparatus. This simple method permits accurate record to be kept of the quality of the slabs turned out. The av-

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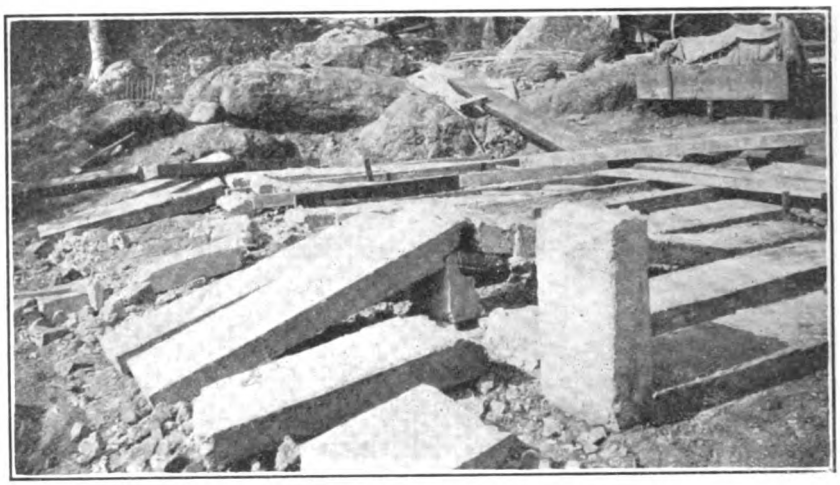
erage labor-cost of forms, and mixing and placing 1700 cu. yd. of shapes, was $2.40 per cu. yd. The most expensive week's run was $4.88 and the least expensive $1.72. The average probable cost per cubic yard of shapes ready for hoisting was:

Aggregate	$2.00
Cement	4.50
Reinforcement	3.50
Mixing and placing	2.40
Forms and incidentals	0.50
	$12.90

The labor cost of hoisting includes operation, switching, shifting, and loading cars. Though a crew of some three men was employed in loading slabs, their wages were charged direct to the cost of hoisting, and the cost of loading and hoisting the slabs is given as the average of all cars of concrete material hoisted. This total labor cost is charged only against cars of concrete material and slabs. The labor charge includes also the cost of moving all supplies. The average cost of hoisting some 3700 cars of slabs and concrete material was $2.05 per car, each car carrying about 1½ cu. yd. All power was furnished by steam made with fuel oil. The probable field cost of hoisting per cubic yard was very nearly:

Labor	$1.50
Fuel	0.50
Plant	1.00
	$3.00

It was realized from the first that the chief difficulties would be with the transportation of material. A 30-in. gauge railroad was laid along the bottom of the conduit line, the first mile of 16-lb. rail, the remainder of 12-lb. rail. The 16-lb. rail was much the better and caused fewer derailments. This track was kept in the best condition, the material necessary to line the bottom and sides of the conduit being just enough to properly ballast the railroad. A good equipment of both flat cars and box cars was secured. The box cars for hauling the concrete material were of the gable-bottom type, 1½ cu. yd. capacity, and were found to be most satisfactory for this service. Two slabs were loaded on a flat car at a time. These weighed nearly 4000 lb. apiece, and as the cars were 4-wheeled, with both sets of wheels rigid, consider-



BROKEN CONCRETE SLAB TEST PIECES.

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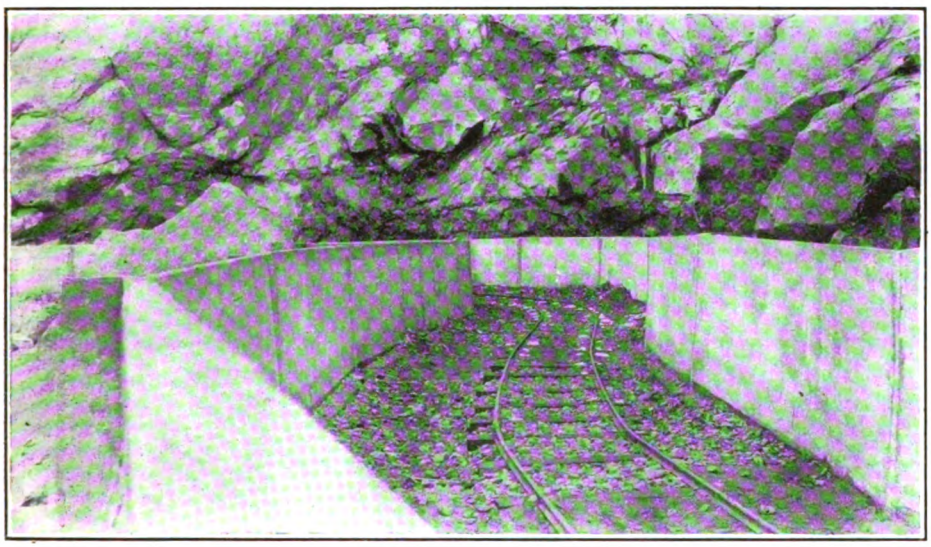
able trouble was had with broken axles due to the sharp curves. The conduit line follows a contour of the hillside, and as a consequence, curves were very short and there were lots of them. Curves of 12 to 20-ft. radius were common. Flat cars finally were constructed with eight wheels, two trucks of four wheels each, swiveled at each end of the car and with a short wheel base. These cars gave good service, seldom went off the rails, and stopped the breaking of axles. A 2½-ton gasoline locomotive was heavy enough, as on account of the sharp curves a longer train than four or five cars would have but brought more trouble. The engine had four cylinders and was of 20-hp. capacity, altogether a rugged little machine. It had four wheels rigidly fixed to the frame. With all due respect to gasoline locomotives in general, it was surprising how many parts of this one could get out of order. It would take quite a list to enumerate them, and even if all of the parts were in fine working condition, the machine would climb off the rails at the first curve. This was partly overcome by substituting for a pair of rigid wheels, a swivel truck of four wheels. After this change, the machine would stay on the track fairly well so long as it traveled with the swivel truck in front, but went off the track worse than ever if the machine tried to go backward. A turntable was finally provided at each end of the run. The average labor cost of moving 3700 cars of concrete material was $1.50 per car. This includes all track work, operation of the transportation system, and unloading concrete material. It does not include unloading slabs. As in the case of hoisting, some 25% of this number of cars was loaded with supplies. The above average is the total cost of transportation divided by the carloads of concrete material. The field cost per cubic yard for transporting concrete material was as follows:



CONCRETE SLAB DOUBLE BENCH CONSTRUCTION.

Labor	$1.00
Plant	1.00
Extras	0.50
	$2.50

The best week's run was 220 cars

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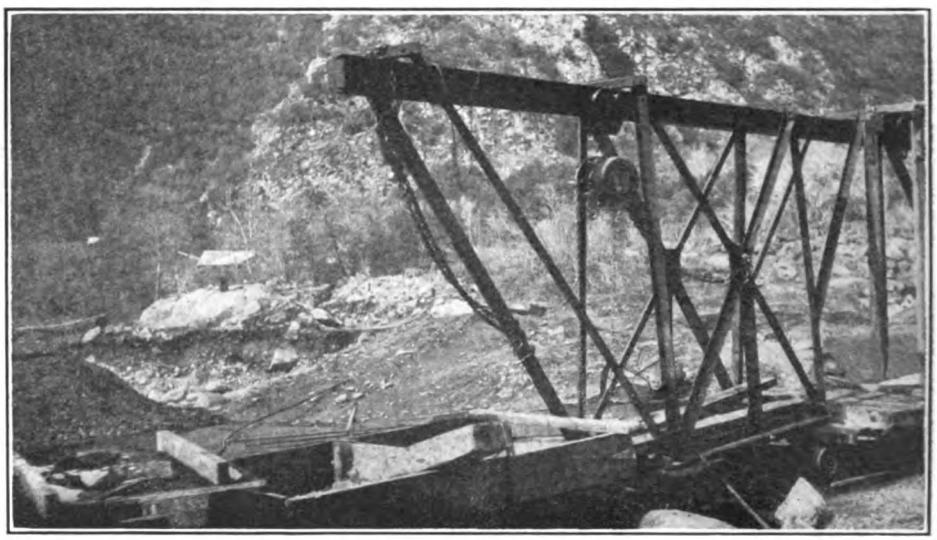
when the locomotive was delivering material close to the head of the hoist and a mule was being used to deliver cars along the flume. Almost all the material for the flume was so delivered. The best week's run as to cost was 40c. per cubic yard and the poorest $2. During two weeks in December 1912, 246 cars were delivered at the end of the conduit line, 18,000 ft. from the head of the hoist, at an average cost of $1 per cubic yard.



PORTABLE DERRICK USED IN HANDLING SLABS.

As pointed out above, fully one-half of the construction plant was due to excavating and should be charged to that account. Any kind of construction work would make necessary almost all of the remainder; in fact, this slab construction called for only two pieces of special apparatus, namely, two cars that cost nearly $350 each on the job. These 'flying machines,' as the boys called them, were used in loading slabs and in unloading and setting both flume and bench slabs.

If the conduit had been designed as a timber flume, one-half of the construction plant equipment, namely that used in excavation, would not have been necessary, but we could not have done without the hoist, railroad cars, and locomotive. In unloading and setting, flume slabs were picked up, run to the centre of the car, the car turned about its centre one way or the other, and the slab lowered into place. A crew of four or five men could easily set eight to ten of the 12-ft. sections of the flume per day. When the flume was assembled it was found that no braces had to be used; the caps were set on the posts, the side slabs on the caps, and the bottom slabs on the side slabs. It was found that the structure was so rigid that the railroad could be laid right in this newly assembled flume before any of it had been tied together with concrete, and the work of constructing the flume carried along. One piece of flume 1000 ft. long was thus set up, and not a brace was used. The railroad was extended until the 1000-ft. section was assembled. Then the railroad was removed, joints were con-

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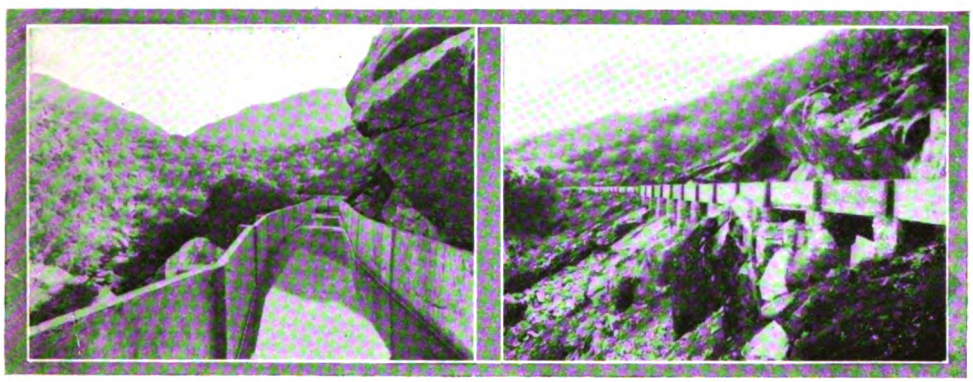
creted, and pilasters poured.

The best week's run in assembling the flume was 38 sections at a labor cost of $2.50 per section. The average week's run for a total of 270 sections was 18 sections at a cost of $3.80 per section. The forms for the pilasters were made of heavy galvanized iron stiffened with angle iron. They were easily tied into place with wire and then filled with concrete. The forms were greased inside with crude oil, when instructions were followed, and left in place for 24 hours. The joints in the bottom of the flume were made of mortar, at the same time that the pilasters were put on. Making the joints of mortar was a mistake for the reason that mortar, in setting, contracts, and the joints had to be gone over four or five times and re-worked in order to make them tight. If the joints had been of concrete, this trouble would have been avoided. The average labor cost of pouring the joints and placing pilasters was $2 per 12-ft. section.

The flume, as designed, was to have been supported on concrete posts 12 by 12 in., molded in the yard at the same time as the other shapes. As actually built, part of it was carried on 12 by 12-in. posts molded in place, and a part on masonry piers 3 by 3 ft. Some of the masonry piers had a content of more than 2 cu. yd. The labor cost of placing some 400 cu. yd. of masonry in the headworks was nearly $6 per cu. yd. and 4.3 sacks of cement was required. The piers must have had a greater unit cost per cubic yard, and though no data on the cost of the piers themselves are available, I believe that some cost as much as $50 to $75 per pair. The average cost of grading and footings, both labor and material, that is, of getting the supports ready for the flume, was $20 per 12-ft. section. The flume was 3 by 6 ft. inside and it is probable that the total cost per 12-ft. section was as follows:



INSIDE OF CONCRETE SLAB FLUME.

COMPLETED CONCRETE SLAB FLUME, SHOWING MASONRY SUPPORTING PIERS.

Shapes	$43.20
Assembling	3.80
Joints and pilasters	3.25
Footings	20.00
	$70.25

This cost includes labor, material, and plant charges, in other words, it is probable that the total field cost of constructing this concrete flume was slightly less than $6 per lineal foot. This

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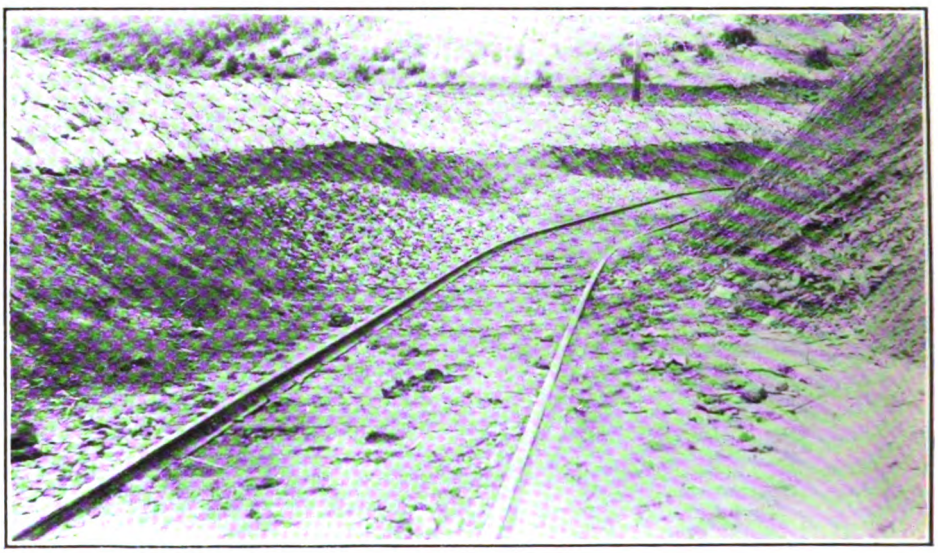
cost is equivalent to that of a wood flume complete and erected in place at $75 per 1000 board feet. I believe that the timber flume, if built under these same conditions, would cost $75 per 1000. In fact, though the Tule river flume was built of a cheap grade of mountain pine, $75 per 1000 very closely approximates the total cost in place of the lumber put into this structure. In the light of the experience gained on this work, I would not hesitate to say that under the same natural conditions this concrete flume could be duplicated for $4 per lineal foot or equivalent to the cost of a timber flume at $50 per 1000.

The flume was finished in December 1912. Two bulkheads were put in and the water was turned in. The absence of leaks was most gratifying, absolutely not one leak appeared between the ends of the slabs at the pilasters where the leaks were most likely to occur. A slight darkening due to dampness appeared upon the outside of the thin side slabs, but in no case was there a dripping leak. There were two sections of about 100 ft. in length where there were leaks through the floor joints due primarily to the fact that the joints were frozen before they had time to set. Only one shape developed a weakness when the load came on. One floor slab broke and was replaced. It was intended to have the water flow within 6 in. of the top. To regulate this, a small concrete siphon was built over the side of the flume, so let into the side that the water would flow through by gravity if the head on the flume got above 2 ft. 6 in., and with a water seal on the outer end. Hardly a hatful of water was required to exhaust the air. Then the siphon would carry a full load. During the cold spell it drew almost all the water out of the flume by building an extension on itself inside the flume in the form of ice.



TRAPEZOIDAL DITCH SHOWING DRY ROCK PATCH WORK.

The flume as it stands is good. It is good to look at, and it is a very strong and rugged piece of construction. It may be easily repaired if that should ever be necessary, but with such sub-

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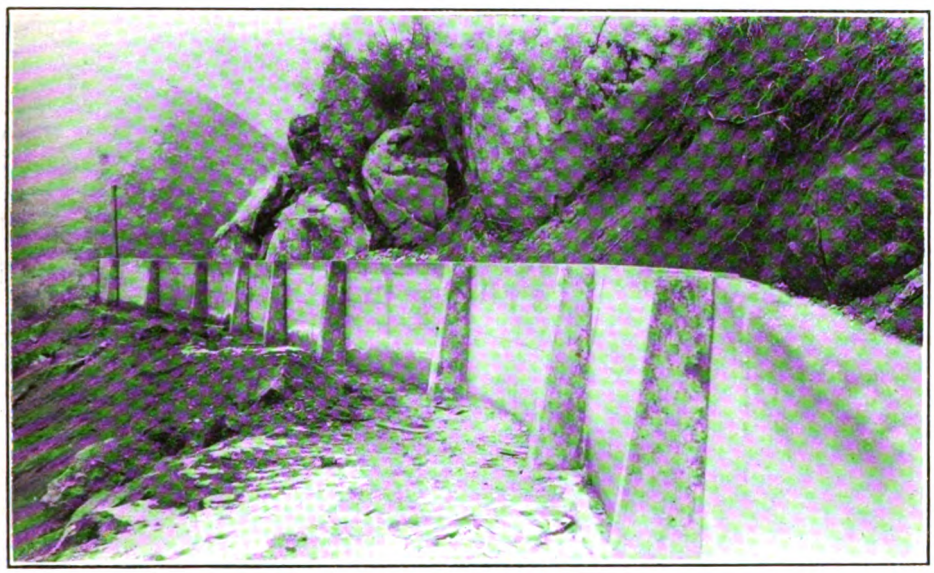
stantial construction as was adopted, damage is not likely. One thing is sure, it is absolutely rot-proof, fire-proof, and can easily be made proof against leakage, three notable points in its favor as compared to a timber flume. As to cost, I believe it is just as cheap as a timber flume would have been under the same conditions. A flume made of timber of a good quality could not have been built for less than $75 per 1000, and it would have taken nearly 900 ft. board measure to replace one of these 12-ft. sections. Construction of this concrete flume has confirmed my opinion that, all things being equal, a concrete flume of this type can be put in just as cheaply as a timber flume.

The main conduit line, which is built of concrete-lined ditch and bench construction offers a comparison still more in favor of the concrete. The trapezoidal ditch was excavated over the easier part of the conduit line, its bottom and sides being dressed to receive the concrete plastering, and at every point it was attempted to make the downhill side of the ditch 3 ft. in cut. In places, the fill above this 3-ft. point slid out, and this was repaired by putting in a dry rock wall as shown in the illustration at a total cost of about 30c. per lineal foot of the ditch as repaired. Of the 6000 ft. of trapezoidal ditch, approximately 1500 ft. was so repaired.



CONCRETE SLAB BENCH CONSTRUCTION.

The concrete-lined ditch cost per lineal foot as follows:

Excavation	$3.00
Concrete aggregate	1.50
Cement	0.75
Mixing and placing	0.50
	$5.75

Bench construction, with slabs on one side, was put in where the excavation to be done was in earth, but the slope of the ground was such as to prohibit the excavation of a trapezoidal ditch. A bench at least 10 ft. wide on solid earth was made with the uphill-side sloping one on one. The bottom and uphill-side was smoothly dressed to receive the 3-in. thick plastering of con-

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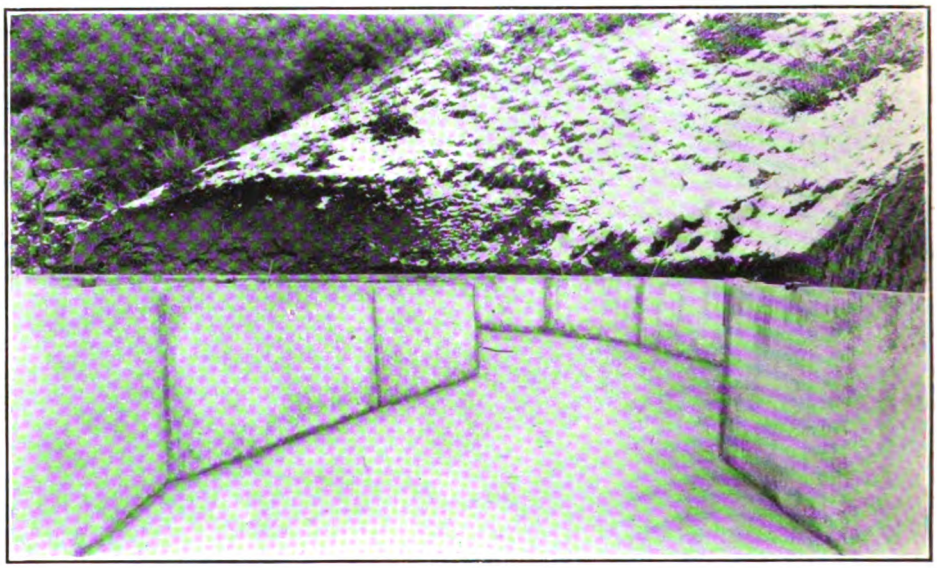
crete as in the case of the concrete-lined ditch. Bench construction with slabs on both sides was used where the character of the excavation was such that it was not practical to put in the single-slab construction with the uphill-side excavated on a slope of one on one. A bench at least 12 ft. wide on solid earth was made with the uphill-side breaking off irregularly and as nearly perpendicular as it would stand. Slabs were unloaded, both in the case of the single-slab and double-slab construction, with the 'flying machine.' About six men made up a crew. The slabs were unloaded, leveled, and left standing without being braced till the pilasters were ready to be poured. The lip of the 'L' served to make them stand without being braced and also served as a lap joint between sides and bottom, thus minimizing the possibility of leakage. The best week's run of setting slabs was 108 slabs at an average cost of 50c. per slab. The average number of slabs set per week was 42 at an average cost of $1.35 per slab. Pilasters were put in at the end of the slabs just as in the flume construction and under the pilasters was put a substantial concrete foundation. The average cost of placing pilasters and foundations was nearly $1.35 each.

The probable total cost per lineal foot of single-slab bench construction was as follows:



FINISHED DOUBLE-SLAB CONCRETE CONSTRUCTION.

Excavation	$3.00
Slab	1.00
Pilasters and foundation	0.25
Concrete aggregate	1.00
Cement	0.60
Mixing and placing	0.50
	$6.35

The probable cost per lineal foot of double-slab construction is as follows:

Excavation	$3.00
Slabs	2.00
Pilasters and foundations	0.50
Concrete aggregate	0.75
Cement	0.50
Mixing and placing	0.50
	$7.25

This main conduit line has a water-carrying cross-section of 33½ sq. ft.

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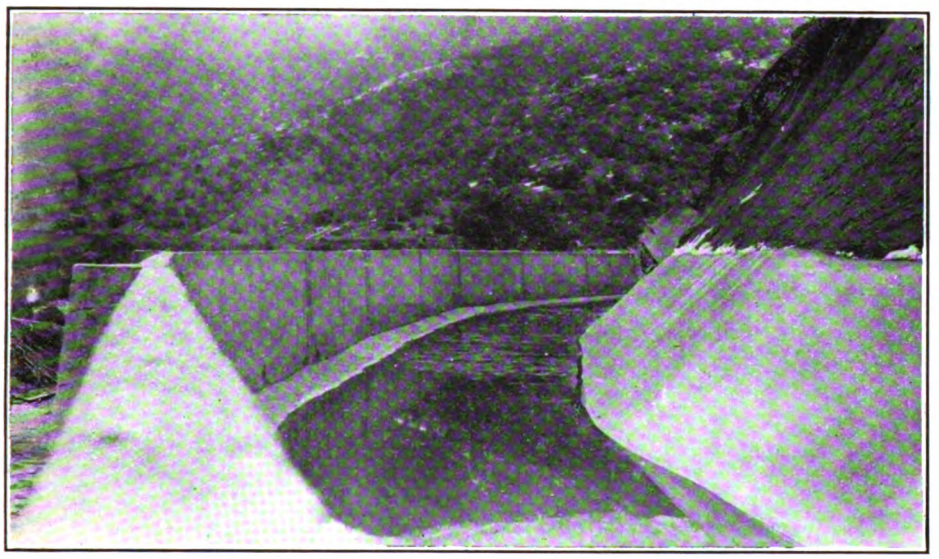
and has a total cross-section of 38 to 40 sq. ft. A timber flume of good design having this cross-section would require 150 ft. board measure per lineal foot. This at $75 per 1000 would make the timber flume cost, completed, $11.25 per lineal foot, or nearly twice the cost of the concrete conduit. A concrete flume of the same size and under the same conditions would have cost less than $10 per lineal foot and could be duplicated for $7.50 per lineal foot.

The probable average total field cost of this main conduit line built of concrete, namely $6.35 per lineal foot, is equal to the cost of a timber flume where the total cost of the finished flume is $42 per 1000. This cost of $6.35 per lineal foot of conduit represents the cost of the first job of its kind. I believe under the same natural conditions, with a slight change in the transportation equipment and with a full realization of the fact that all the troubles lie with transportation, this main conduit could be built of concrete of the same design for $5 per lineal foot, or equal to a wood flume at a cost of $33.35 per 1000 in place. This surely is approaching bedrock prices on the cost of the wood flume. In the way of natural conditions, this job was about as unfavorable for concrete construction as a job could be. All material had to be hauled some 22 miles over a mountain road. This not only made the freight high, cement costing, delivered on the job, $5 per barrel, but it was so far from the source of supply that every few days expensive delays occurred due to inability to quickly procure repair parts for the construction plant equipment.



FINISHED SINGLE-SLAB CONCRETE CONSTRUCTION.

There are a great many points in favor of this concrete design. It is a rugged structure. It requires a minimum of material. The form work is very simple and inexpensive. The shapes are easily transported and readily assembled, requiring very little special equipment, and being practically as easily moved as ordinary concrete aggregate. The joints are easily made and kept water tight, and at the

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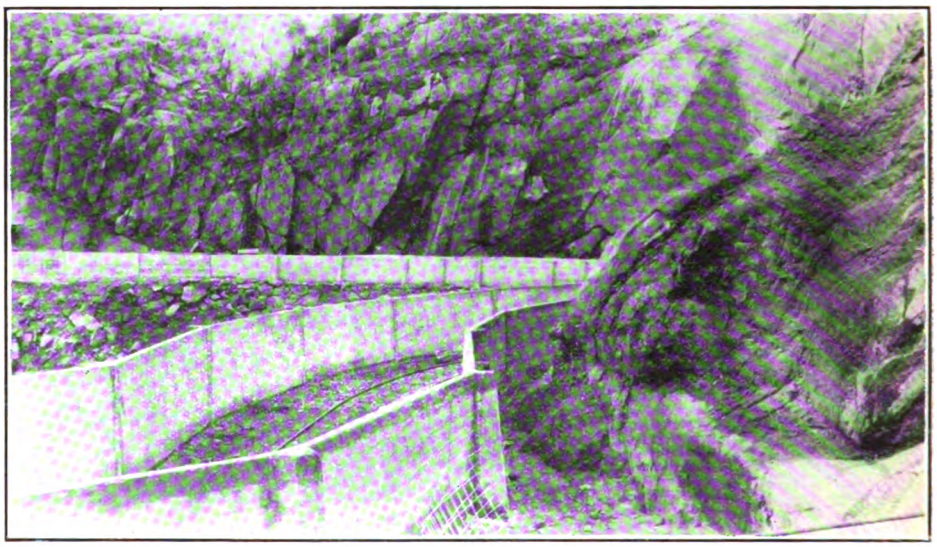
same time it is a concrete structure easy to repair. I believe that a mere visual inspection will convince anyone that nothing short of an earthquake or a landslide will necessitate repairs. There is no way to avoid such things, but loose rocks rolling down can be prevented to a certain extent and extra excavation here and there can be done to avoid accidents. Of the four types of concrete conduit, I believe the double-slab bench construction is the best, though all the other types will find places in which they will fit most excellently. The concrete-lined conduit is the cheapest and can be most readily pushed in its construction, but it, as well as the single-slab bench construction greatly disturbs the hillside, so that if the ground is disposed to shift, neither of these types is safe. Concrete plastered on the sloping uphill-side of both the trapezoidal ditch and single-slab bench construction does not have sufficient strength to resist the movement of the underlying material. On the other hand, for the double-slab bench construction, the excavation of a narrow bench but slightly disturbs the loose material of the hillside. When the slab is set in next to the uphill bank of the bench, and has been filled in behind with material, this slab is strong enough to resist any movement of material behind it. When the conduit is finished, the material of the hillside is just as stable as ever. If the soil is of such a nature as not to drain readily, it would be well to put drainage tile under the bottom of the double-slab bench.



CHARACTER OF GROUND ALONG CONDUIT RIGHT OF WAY.

The double-slab bench-type of construction has many advantages over the concrete flume. It is cheaper than the flume and its load is distributed over the entire bottom so that ground of almost any character will carry the load. With a flume, expensive foundations cannot be avoided. It is simpler to build than a flume. A railroad can be laid along the bottom of the conduit, and if cars are arranged so that slabs can be unloaded without the help of a derrick, all switching is made unneces-

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sary. In other words, a trainload of slabs is brought down from the yard and distributed where required. Then, of course, after the cars have been unloaded and hauled back out of the way, the slabs have to be set with the derrick.

In the case of the flume, however, unless provision is made for delivering the slabs alongside, it is necessary that they be delivered through the flume as it is built. The slabs have to be unloaded and set with the derrick, and where the flume is being erected a long way from the source of supplies, the question of switching and the consequent delivery of material becomes troublesome. The flume, however, can be made very useful in the crossing of gulches and in troublesome ground, but where the nature of the ground will permit, I believe that the double-slab bench construction is the best.

In an all-concrete construction job, natural difficulties are easily overcome, while those likely to arise in crushing a lot of rock and sand are few. The chief difficulties likely to arise are those of transportation, not alone in the transportation of slabs themselves, for the shapes are no whit more difficult to handle than cement and ground rock, but the distribution of several thousand yards of ground rock and sand in a line about six miles long along the mountain side is likely to prove troublesome at the best, unless the system of transportation is well organized, equipped with proper tools, and, most of all, directed by a man full of push and ginger.

The concrete flume has been finished some three or four months and filled with water. All material for the 18,000 ft. of main conduit line from the siphon to the head of the main pressure pipe has been delivered and a considerable amount of concrete has been placed in the bottom and on the sides. Nothing has been done on the 4000 ft. of main conduit along the east side of the Marble fork other than the excavation. Patents have been granted to me on the concrete-flume type of construction and applied for on the concrete-bench type of construction.

Street Improvements at Walla Walla in 1912

By W. R. REHORN*

THE city of Walla Walla includes all of the land in section 20, the east three-quarters of section 19, the north three-quarters of section 29, the west three-quarters of section 21, three 40s in section 28, and part of section 30, all in township 7, range 36, E.W.M., containing 3.80 square miles of land surface. There are in the city of Walla Walla about 66.6 miles of streets, varying in width from 40 ft. to 100 ft., with about 26.3 miles of unimproved streets and about 40.3 miles of improved streets. The improved streets consist of all the graded streets, together with those that have been per-

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manently improved by paving or macadamizing. The unimproved streets were principally on the outer edge of the town and in thinly settled districts. The larger part of the graded streets are in good condition because of the work done by the street department in grading and shaping them so as to give drainage. No accurate record has been kept of the cost of the grading, as a great deal of this class of work has been done by private contracts.

There is a total of 148,900 sq. yd. of asphalt pavement, laid at an average cost of $2.15 per sq. yd. and at a total cost of $440,211 for the improvement complete. The first asphalt pavement was laid in the year 1904, some of which is now in poor condition and is in need of repairs. The total length of pavement of this class is 5.65 miles.

There are 64,820 sq. yd. of bitulithic pavement, making a total length of 2.24 miles, laid at a cost of $2.17 per sq. yd. and a total cost of $162,790. This pavement was laid in 1905 and 1906, and has given satisfaction, but a portion of it is showing the need of a top, or what is known as a 'squee-gee' coat.

All of the brick pavement that we have was included in the first asphalt contract and was used only for the gutters and for the alley crossings. There is 3409 sq. yd. of this class of pavement, costing $3.50 per square yard.

Concrete pavement, up to the present time, has only been used for paving the alleys. There are now 13 alleys paved with this class of pavement, containing 8155 sq. yd. and having a total length of 0.80 mile. It was laid at a cost of $1.25 per sq. yd. and a total cost of $11,857 complete. The first of this pavement was laid in 1911, and has not been in use for a long enough time to permit any definite conclusion as to its durability and the service that it will give. Up to the present time it has given entire satisfaction.

The first Dolarway pavement was laid in the fall of 1912, so no conclusion can be formed at this time as to the length of life or service it will give. There is 13,000 sq. yd. of this class of pavement, costing $1.30 per sq. yd. with a 5-year guarantee bond. The total cost of this improvement was $23,000, and the total length is 0.73 mile. The total cost of all the pavement complete, including grading, curbing, draining, paving, etc., was $637,857, and the total length of the pavement amounts to 8.42 miles.

On January 1, 1912, the city of Walla Walla had approximately 33.94 miles of sewers, of the different sizes as follows:

Inch.	Miles.
6	14.73
8	11.00
10	2.33
12	1.56
15	1.42
16	0.46
18	1.22
20	0.21
24	1.00
Total	33.93
Manholes	430.00

The cost was approximately $170,000.

During the year there was laid 3417 lineal feet of 6-in. sewer, 6000 lineal feet of 8-in. sewer, and 4138 lineal feet of 10-in. sewer, together with 40 manholes, costing $10,625 for the sewers complete.

In 1910 there were sidewalk permits issued for 7338 lineal feet of 6-ft. sidewalk. In 1911 there was 22,010 lineal feet of walk laid. Sidewalk permits were issued for 20,810 lineal feet, and the miscellaneous amounted to 1200 lineal feet. During the year 1912 there were 213 sidewalk permits issued calling for 24,780 lineal feet of walk. Local

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improvement districts were formed for 5700 lineal feet, and other than this there was laid approximately 2000 lineal feet, or a total of 32,480 lineal feet of walk, which cost approximately $26,000.

CONTRACTS LET AND WORK DONE DURING THE YEAR 1912

PAVEMENT

Kind.	1904.	1905-6.	1909.	1910.	1912.
Asphalt—Number sq. yd.	27,214	.....	73,265	46,334	.....
Cost per sq. yd.	$2.50	.....	$2.13	$2.00	.....
Bitulithic—Number sq. yd.	.....	64,820	.....	.....	.....
Cost per sq. yd.	.....	$2.17	.....	.....	.....
Brick—Number sq. yd.	3,409	.....	.....	.....	.....
Cost per sq. yd.	$3.50	.....	.....	.....	.....
Concrete—Number sq. yd.	.....	.....	.....	.....	7,487
Cost per sq. yd.	.....	.....	.....	.....	$1.24
Dolarway—Number sq. yd.	.....	.....	.....	.....	13,000
Cost per sq. yd.	.....	.....	.....	.....	$1.30
Curbing—Number lin. ft.	7,971	13,704	27,210	18,390	7,500
Cost per lin. ft.	$0.40	$0.40	$0.50	$0.50	$0.60
Excavation—Number cu. yd.	14,633	14,113	29,873	23,605	5,775
Cost per cu. yd.	$0.58	$0.35	$0.70	$0.60	$0.40
Total cost of improvement	$102,677	$162,789	$206,482	$131,052	$ 33,864
Total yardage (sq. yd.)	30,623	64,820	73,265	46,334	20,487

STREETS

Width, ft.:	40.	50.	60.	65.	70.	80.	100.	Total, miles.
Unimproved	1.5	4.23	9.12	1.96	1.30	7.37	0.81	26.29
Improved	0.25	0.52	15.00	0.73	2.05	19.50	2.24	40.29
Total	1.75	4.75	24.12	2.69	3.35	26.87	3.05	66.58

IMPROVED STREETS

Roadway width, ft.:	20.	28.	30.	34.	36.	40.	44.	48.	60.	68.
Asphalt	300	3535	....	4,648	675	300	301	10,825	9,262	....
Bitulithic	300	....	2718	.....	...	1780	625	3,558	1,753	1080
Concrete	7788	....	....	.....	...	....	...	.....	.....	....
Dolarway	...	950	....	2,900	...	....	...	.....	.....	....
Macadam	...	....	....	12,524	...	....	...	2,712	.....	....
No. lin. ft.	8388	4485	2718	20,072	675	2080	926	17,095	11,015	1080

Total length of improved streets by permanent improvements, 68,534 lin. ft. or 13 miles.

PAVEMENT

Kind.	Yardage.	Cost.	Length, ft.	Cost.
Concrete	7,487	$1.24	3905	$10,864.20
Dolarway	13,000	1.30	3850	23,000.00
Total	20,487		7655	$33,864.20

WATER MAINS

6-in., 2333 lineal ft., at 72c. per ft. Cost complete, $1854.

CONCRETE SIDEWALKS

32,600 sq. ft., 5700 lineal ft.; average cost per sq. ft., 13.1c.; total cost, $5896.64.

SEWER

Size.	No. lineal ft.	Av. cost per lineal ft.
6-inch	3417	56.5c.
8-inch	6000	58.0c.
10-inch	4138	67.7c.
Manholes	40	$48.12 per manhole

Total cost of sewers complete, $10,625.65.

GRADING

Excavation ....2898 cu. yd. at 30c. per cu. yd.
Embankment ..3356 cu. yd. at 50c. per cu. yd.
Total cost of improvements, $2654.54.

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BRIDGES

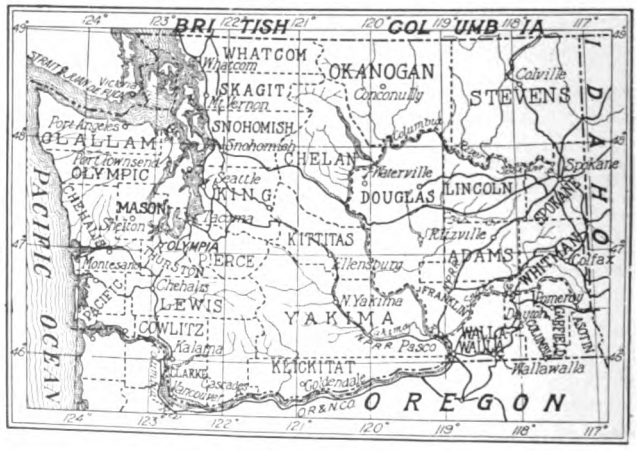
The city of Walla Walla has 21 bridges, 13 of these crossing Mill creek and 8 crossing Garrison creek.

The bridges crossing Mill creek are as follows:

Streets.	Embankment.	Kind.	Cost.
Roosevelt	1 concrete, 1 pile	wooden truss	$ 1,000
Clinton	concrete	24-in. steel girders	6,000
Park	concrete	20-in. steel girders	6,000
Otis	1 concrete, 1 pile	wooden truss	1,000
Palouse	2 masonry	combination deck	2,000
Spokane	2 concrete	reinforced concrete	10,000
Main	2 concrete	reinforced concrete	10,000
Second	2 concrete	20-in. steel girders	3,000
Third	2 concrete	reinforced concrete	17,500
Fourth	2 concrete	reinforced concrete	15,444
Fifth	2 concrete	wooden girder	2,000
Sixth	2 pile	wooden girder	500
Thirteenth	2 pile	wooden truss	400

Bridges crossing Garrison creek:

Streets.	Embankment.	Kind.	Cost.
Division	2 pile	wooden truss	$ 600
Bryant (two)	2 pile	wooden girder	....
Howard	2 pile	wooden girder	600
Second	2 pile	wooden girder	....
Third	2 pile	wooden girder	300
Chase	2 pile	wooden girder	350
Ninth	2 pile	wooden girder	600
		Total	$76,694



THE STATE OF WASHINGTON.

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The Engineering Digest

A Sewage System for a Small Town*

By J. E. TUPPER†

THE city of Pomeroy, Washington, is the trade centre for an agricultural population of 5000. It is the county seat and the terminus of the only railroad in that county. The present population of the city is about 1800, of which 1500 are included in the sewered area described in this article. With the exception of one flour mill there is no manufacturing industry in the city, nor is there any prospect of there being any in the future. It is a city of residences, and because the homes are owned by people who are accustomed to having unlimited space in which to move about, the residence lots are large, the average being 120 by 120 ft. This condition necessitates abnormally long lines of sewers, the average per capita distribution being only 60 per 1000 ft. of laterals exclusive of main and intercepting lines.

The city is in a narrow valley having an average axial incline of 50 ft. to the mile, toward the west. The hills on either side rise rather abruptly to a height of from 400 to 600 ft. The Pataha creek flowing through this valley in a deep, and for much of the way artificial channel, forms an ideal central artery for the storm-water drainage.

The sub-soil consists mainly of a rather porous clay intermixed in places with considerable gravel and boulders and is underlain at varying depths with thick strata of porous gravel. The sub-surface drainage is exceptionally good. With the exception of two small areas where springs exist, ground water never troubles any part of the city and cellars are universally dry throughout the year. The nature of the sub-soil is such that for the most part trenches can be dug to any reasonable depth without shoring.

The water supply for domestic purposes is ample, 230 gal. per capita per 24 hours. It is obtained from a large mountain spring three miles from town and flows by gravity through a 10-in. steel main to the two storage reservoirs from which it is drawn as needed into the distributing mains. These reservoirs have a combined capacity of 530,000 gal. The only fault to be found with the water system is that the distributing pipes were installed a little at a time without engineering advice or supervision and without any plan or record.

The area to be served by the system has an extreme length of 6600 ft. and an average width of 1500 ft. The principal streets and alleys follow very closely the general course of the axis of the valley. The descent from the sides of the valley toward the centre is in all cases sufficient for sewer gradient, and in those tracts along the hillsides that are suitable for building sites the descent is too abrupt for the best service. It was evident at once that the sewer lines must of necessity run parallel with the axis of the valley and that junction with the trunk line must be made by intercepting lines.

As the location of the trunk line would be dependent to a large extent on the location of the disposal works this was the first point to be taken up and settled. No suitable location could be found on the north side of the valley within a reasonable distance unless dependence was had upon filtration exclusively. On the south side three locations were considered, one being about 700 ft. west of town, one 4000 ft., and one 6000 ft. distant. The nearer location was selected and a tract of two acres was secured. Owing to the relatively slight elevation of this tract above the creek bed into which

*Abstract from *Engineering & Contracting*, March 12, 1913.

†City Engineer, Pomeroy, Washington.

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the sludge must discharge, in order to avoid pumping it, it was necessary to use a comparatively shallow tank and approach it with a sewer gradient of 0.5%. A plan and section of the sedimentation tank is shown in Fig. 1.

A gradient of 0.5% was taken as the minimum limit throughout the system. This location of the disposal works, together with the topographical features of the city, determined the location of the trunk line on the south side of the creek, following the course of the stream as closely as the position of the streets and alleys would allow. As the trunk line must serve as a local sewer for the territory through which it passes, the location, with due consideration for the above feature, was also determined with the object in view of getting the maximum amount of local service.

Before proceeding to the location of the laterals it was first necessary to determine, tentatively, at least, the location of the intercepting lines. This was especially true of those connecting with the north side system of laterals, as they had to be led across the creek, and suitable locations for these crossings could not be found at random.

An examination of the topography of the city showed that the area on each side of the creek is divided into three natural basins by spurs of sufficient elevation to make it inadvisable to attempt to cut through them if such a course could be avoided. It may as well be noted here that no attempt has been made, or is likely to be made, to reduce the streets of the city to a system of uniform grades. The grades of the streets change at each street intersection as a rule, and, as none of the grades on the principal streets exceeds 5%, it is not likely that any material change will ever be made.

This natural division indicated the advisability of planning a separate system of laterals for each basin and of locating the intercepting sewers so that they would enter the lowest point in each basin as nearly as other conditions would allow. Provision had to be made for a future extension of the system to the east to include territory that

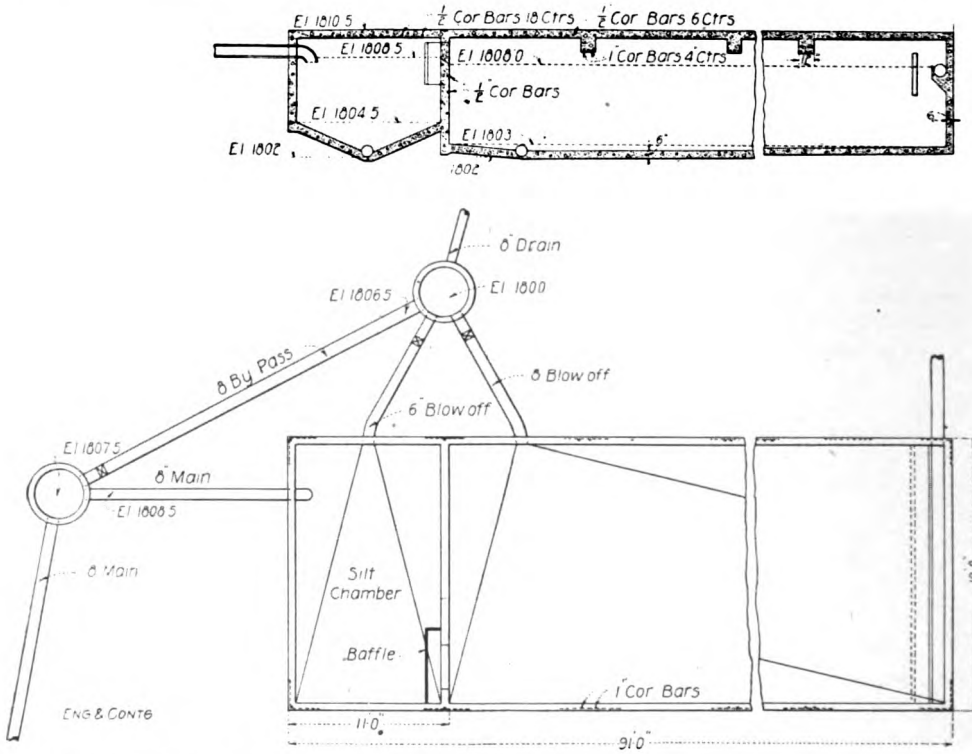

FIG. 1. PLAN AND CROSS-SECTION OF SEDIMENTATION TANK AT POMEROY, WASHINGTON.

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is as yet too sparsely settled to warrant the installation of laterals. A careful survey was made, however, and a tentative plan for two additional lateral systems was prepared. A portion of one of these districts, including the intercepting sewer, was included in the present scheme.

The plan as thus developed called for crossing the creek at four points; that is, with the first, third, fifth, and seventh intercepting sewers, and the question of how it would be done presented a serious problem. The stream has its origin in the nearby mountains and in flood times becomes a raging torrent. At the first crossing the stream flows in a recently constructed artificial channel which is being deepened and widened by each flood. Where it would eventually find its permanent bed was so problematical that it was deemed better to provide a temporary overhead crossing by means of a steel pipe resting on piling. The elevation of the sewer flow line at this point was well above the probable crest of any ordinary flood, and it seemed safer to take the chances of its being broken by an unusually high flood rather than to expend more in the construction of a submerged crossing under the uncertain channel conditions.

The third intercepting sewer was too low to be carried overhead and a submerged crossing was necessary. The water in the stream, which was low at the time, was flumed by the point. A trench 2 ft. wide and 3 ft. deep was dug across the channel and a 6-in. vitrified clay sewer pipe was laid in this trench. The trench was then filled with portland cement concrete to within 6 in. of the bed of the stream and the filling was completed with hand-placed boulders bedded in the fresh concrete.

The pipe was given a slope of 2% in the direction of the sewage flow, and concrete manholes were constructed on either bank connecting it with the sewer. The bottom of the upper manhole had a decided slope toward the crossing pipe, while that of the lower manhole was sunk 1 ft. below the bottom of the pipe, thus forming a sump for the collection of silt. The depth of this submerged crossing is 10 ft. below the flow line of the sewer, and its operation has been very satisfactory. The conditions at the other two crossings were such that it was found advisable to erect overhead crossings, using lap weld iron pipe resting on concrete piers.

The most serious problems were met in locating the laterals. The question of whether the sewers should be located in the streets or in the alleys was a bone of contention.

By locating the sewer along the north side of the street just outside the gutter line, we reduced the total length of branches for that side to 150 ft. The sewer in the alley adjacent required 370 ft. of line and 80 ft. of branches, making a net saving of 200 ft. of pipe, besides saving the extra depth of trench. This alley sewer also serves the other half block which otherwise would have to be served by the sewer on the opposite side of the adjacent street with an additional total length of branches of 300 ft. This same reasoning applied in the case of three laterals that were objected to by the consulting engineers on the ground of lack of concentration of the sewage. This reason appeared to us to lack pertinency. The laterals are readily flushed and kept sanitary even when carrying the minimum amount of sewage, while the service branches can only be flushed through the house fixtures, and cleaning them is a difficult job.

Manholes were placed at each change in either alignment or gradient. Absolutely straight alignment, both vertical and horizontal, between manholes was insisted upon. The maximum distance between manholes was set at 740 ft. This may seem to be rather far, but for a system of this nature and size it was deemed adequate. Where the distance exceeded 400 ft., lamp holes were placed at or near the midway point.

All manholes were constructed of concrete over steel forms that I designed, using a 1:3:5 mixture. The concrete was mixed wet, almost sloppy, and carefully spaded next the inside form. Very little and in most cases no patching was required after removal of the forms.

In deciding upon the sizes of pipe to use, we proposed to provide for a possible future population of 3000, and a probable daily discharge of 90 gal. per capita. Allowing the maximum flow to be 300% of the mean, we have a maximum flow of 1.1 sec-ft. As no factories or large users of water are to be provided for, this was considered ample.

No provision was made for ground-water seepage into the sewers, and we have been justified in this conclusion by the results. Only in one place was any ground-water met

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and this was underdrained for a distance of 2000 ft. As the smallest size of pipe that we decided to use was 6 in., it was found that none of the laterals or intercepting sewers would ever carry sewage to more than half fill the pipes. Applying the same factors to the trunk line and using Kutter's formula for the velocity, we found that an 8-in. pipe has a capacity of 0.8 sec-ft. and a 10-in. pipe 1.4 sec-ft. As the crest of flow is never as high in trunk lines as it is at times in the laterals, and as it is likely to be many years before the system will be required to serve 3000 people, we decided to use the smaller size of pipe.

In planning our sedimentation tank, it was thought best to construct it of sufficient size to meet the requirements of the present service, and to construct an additional chamber when it became overtaxed. Our present tank has a capacity of 63,000 gal., equal to 12 hours' flow of sewage from a population of 1400, which will probably be ample for the next 10 years. The use of existing private septic tanks and cesspools is likely to continue until such time as they become a nuisance.

In providing for flushing the sewers, several schemes were considered. The plan finally adopted by the council was one of my own. At 16 controlling points in the system a 2-in. pipe was connected to the water main, run to the selected manhole, and closed inside the manhole with a 2-in. gate valve. When one of these valves is opened it is found that the flow is sufficient to fill a 6-in. sewer pipe to its full capacity, and it can be allowed to run until a perfect flush is secured throughout the entire length of the lateral. The flow is absolutely under the control of the operator and can be continued until he knows the line is clean. After eight months' operation the plan has been found to give perfect results. The cost has been slight, as the work has been done by the employees who are on the monthly payroll.

The lateral system is now carrying rather more than 95% of the sewage of the district. It has been found advisable to flush these lines twice a week. In the residence districts one flush a week has been found ample, and in some cases once in two weeks is all that is required.

There was considerable question about the successful operation of the drain laid, and leading from the sedimentation tank to the creek. This line is 870 ft. long and could only be given a gradient of 0.5%. A portion at least of this line would be needed in case filter beds should be required to care for the effluent; but we also hoped that we would be able to discharge the sludge through the line without resorting to pumping. Many doubted the feasibility of this course, and one sanitary engineer pronounced it utterly absurd. We decided, however, to give it a fair trial. A manhole was constructed at the head of the line, 20 ft. from the tank, and 8-in. lines with gate valves for closing were run from each chamber of the tank to this manhole. These connecting lines were given a drop of 2 ft. in order that a maximum initial velocity might be given the discharge. The official having charge of the sewers was instructed to open the valves for a short time at least once a month to avoid danger of the sludge collecting in the pipes in sufficient body to effectually seal them. After six months' operation of the system it was decided to give the scheme a test. The main chamber valve was opened and left open until the discharge was quite liquid. It was then partly closed and the silt chamber valve opened. By a careful manipulation of the two valves, he had no trouble in discharging the sludge through the drain line and thoroughly cleaning the tank. The success of the trial exceeded our expectations.

The plans above described were developed by me and constructed under my supervision. Due credit should, however, be given to M. K. Snyder of the State College of Washington, and R. S. Deick, consulting engineer of Portland, Oregon, for helpful suggestions in connection therewith.

After approving and adopting the plans, the city council decided to build the system by city forces. They were influenced in this decision partly by the past experience of the city with contract and force account work, and partly by the itemized estimates of the engineers. They had three itemized estimates and one approximate estimate.

On construction costs, exclusive of rights-of-way, engineering, financing, and contractors' profits, the first estimate was $25,000; one estimate that also excluded the service branches was $21,000; the approximate estimate put it at $24,000, and the city engineer's estimate was $21,000. The total cost was put at $30,000, $27,000, $28,000, and $24,000, exclusive of contractors' profits.

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The street and water commissioner was instructed to proceed with the work by force account under the supervision of the city engineer. The sewer committee of the council was made the purchasing agent, and they practically turned the matter over to the city engineer.

Nearly all the material had to be shipped in from outside points. The following are the quantities purchased and the unit prices paid for the principal items in the supply account:

Materials:

Item.	Unit cost.
3525 ft. of 8-in. sewer pipe at	$0.21
44,120 ft. of 6-in. sewer pipe at	0.13½
1100 branches and bends at proportionate rates.	
275 bbl. cement at	2.65
5800 lb. reinforcing steel at	0.0365
150 cu. yd. sand at	3.00

The following scale of wages was paid for an eight-hour day:

Common labor	$2.50 to $3.00
Man and team	4.50
Pipe layers and engineer's instrument man	3.50
Foreman	4.00
Street commissioner	5.00
City engineer	5.00

The trenching was done by station work on a yardage basis, and the following scale of prices was paid:

Earth, 15c.; hardpan, 30c.; loose rock and cement gravel, 60c. per cu. yd., respectively.

Where unusual conditions exist, such as encountering water mains, tunneling under railroad tracks, or blasting out solid rock, the stations were excavated by the day wage men. The excavation for the tank was done mainly by team and slip scraper, enough men being kept in the excavation to keep the sides trimmed down true. This was essential, as the earth walls of the excavation were used for the outside forms.

The organization of the construction forces was worked out in the following manner. At the head was the city engineer with an office clerk, and in the field an instrument man with two chainmen and a rodman. The field force was provided with transit, dumpy level, self-reading rod, 100-ft. steel tape, stakes, centre tacks, hatchets, picks, shovel, carpenter's square, saw, and hammer.

At the head of the construction forces was the street commissioner with a trench foreman and 15 trench men, more or less, provided with picks and shovels, 6-ft. rods for measuring depth of trench, and a supply of steel wire for overhead line; three pipe-layers with tender and trench trimmer for each, in charge of the trench foreman; a concrete foreman with a sufficient crew and appliances for hand mixing and placing the concrete; a back-fill foreman with four teams and four to six men, back-filling the trenches and also unloading and distributing the supplies and doing the general cleaning up and roustabout work.

Timbers of 4 by 6-in. stock, 6 ft. long, were distributed at 25-ft. intervals along the section of proposed trench by the roustabout.

The position for the manhole at each end of the section was determined by ordinary transit methods, a timber bedded at each point, and the exact centre marked with a centre tack. The chainmen then staked out the line, setting a stake every 25 ft. and running always against the flow of the sewer. A hub was driven and carefully centred at the 100-ft. intervals. The chainmen then set timbers across the trench line at each stake, the hub centres being preserved by means of a triangle and transferred to the timber. The men were required to use care in setting the timbers on a firm bed, level both ways, and with the earth firmly tamped around the ends. Levels were taken on each of the timbers, the elevation, grade, cut and length of target for each timber were computed, and the rodman proceeded to cut targets out of 1 by 4-in. strips and nail them to the timbers so that the end of the target would be exactly 6 ft. above the trench grade. Where the cut was less than 6 ft. the targets were set 1 ft. from the centre of the trench line and a chalk line was stretched over them as a guide for the trenchmen. Where the cut exceeded 6 ft., the line was run along the top of the timbers and the setting of the targets left until after the trench was partly dug.

For transferring the target lengths to the strips, the rodman was provided with a rule graduated to hundredths of a foot, and he was required to place the target number on each piece cut to avoid getting them misplaced as well as for the information of the workmen who were to follow.

As the trenching was to be done by station work, it was necessary to adopt a system of numbering that could be easily understood by the workmen and readily traced out in

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the records. The manholes were numbered serially and the dead ends were designated by letters. The targets were designated by three numbers—the manhole or dead end toward which the trench was being dug, the 100-ft. station within that section, and the sub-station ending at that target. Thus, 44. — 2. — 3. was the third station in the second 100 ft. of the section ending at manhole No. 44.

No transit record was kept, the locations of the lines being determined by street and alley lines rendering this record useless. The only field record was kept in the level book, which was turned into the office every night and the record was transferred by the clerk to the field book.

The yardage of each station and the cost on the earth basis was computed by slide rule and entered, together with the station number. Later the book was taken into the field and the classification noted, and the name of the man excavating at each station entered. The proper correction for classification was then computed in the office, and the corrected amount was credited to each man in a single-entry ledger.

When the levels had been taken on a section and the line stretched, the trenchmen were allowed to begin operations. Each man was assigned a station in the order in which he came upon the section, and when one had completed his station he went to the head of the line and took the first vacant place. The men were expected to keep a record of the number of the stations dug by them as a check on the timekeeper's record. This was found to be a wise measure and enabled us to correct readily any errors that occurred. One mistake we made was in not providing a regular timekeeper. The street commissioner attempted to perform this duty, but his other duties occupied so much of his time that he could not do the work properly. In attempting to save the wages of one man we had much trouble with our records.

The trenchmen were allowed to work as long hours as they pleased, though as a rule they rarely worked more than the eight-hour day, and to take their own time in excavating the station; the only requirement being that they must not leave a station unfinished if by doing so the pipe-layers would be delayed. As the trenchers were paid for what they accomplished and no more, each one attempted to do as much as possible and to increase his pay-check, and the influence of this stimulation was felt throughout the entire force. The engineering crew was kept on the rush to keep ahead of the trenchers, the pipe-layers were chasing them all of the time, and a keen rivalry sprang up between the three pipe-layers; the roustabout teams were frequent recipients of hurry orders for material; the crew on the back-fill were trying to catch the pipe-layers so they could get a breathing spell; and if a man was found 'soldiering', instead of discharging him it was suddenly found that there was nothing in particular for him to do just then and he was sent ahead into the trenches.

The men were treated liberally in the matter of classifications, and the poorest workers were able to make $2.50 per day. The average wage cannot be accurately determined, as no account was kept of the actual time worked; but it was rather more than $3 per day. One man who was on the job from beginning to end, and who kept a record of his time, averaged a little more than $4 for an eight-hour day. The plan proved to be an excellent object lesson on the comparative value of common laborers. The best man on the job was able to accomplish twice as much as the poorest, and seemed to do it with no more apparent exertion or persistent application.

As soon as a section of trench was completed, the trench foreman changed the targets to the centre line of the trench and stretched a steel wire over them, using a set of small pulley blocks threaded with sash cord to take up all slack. Any inequalities in the heights of the targets were adjusted and the wire was brought truly parallel with trench grade and directly over the centre line. The trench was then trimmed to the exact grade and the bottom was left even and smooth.

In laying the pipe, certain deviations from standard specifications were made. No bell-holes were required. The size, length of joint, and strength of the pipe, together with the maximum pressure of the earth cover, seemed to demonstrate that they were unnecessary. The additional cost would have been considerable. Much of the way the trench bottom was in hardpan or cement gravel, and the bell-holes would have had to be dug with a pick. Resting the bell on the trench bottom gave additional room for tamping the back-fill under the lower

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quarters of the pipe where the essential support should come. All these considerations combined were thought of sufficient weight to render the course pursued advisable.

The testing of the grade of the pipe was done from the top of the pipe instead of from the surface of the invert. The deviation of the pipes from a true circle was thought to be no greater than the errors likely to be made in using a testing rod with an arm to insert in the end. No gaskets were used at any point. The trenches were all dry, and there did not seem to be any good reason for bothering with them.

In laying the pipe a pat of mortar was placed in the bottom of the bell of the last pipe laid, and it was brushed down with the hand to a little more than the thickness of the mortar space. The pipe was then inserted and pressed down to grade, the bell end being brought to grade by trimming or filling under it if necessary. The alignment was tested with a plumb dropped from the overhead wire, and the joint was then filled with mortar by hand and pressed well into place and finished with a bevel surface. A straw-filled sack was kept in the pipe and drawn forward as each joint was made to wipe off any mortar that might have been pressed into the pipe. The mortar used consisted of one part cement to two parts of screened sand.

In one instance a storm flooded a trench during the night after the pipe was placed in it and before the back-fill was completed, destroying the alignment and forcing us to take up and re-lay 300 ft. This gave us a good opportunity to examine carefully the perfection of the joints, and very little fault could be found with them. In several places it was found that necessary branches had been omitted, and we were obliged to take out joints and insert the branches. In every case where the pipe had been laid as long as two days, we could only remove a joint by breaking one or two joints of pipe. The mortar could rarely be removed without breaking the bell.

In back-filling, loose earth was thrown in, filling to about midway of the sides of the pipe, and this was carefully tamped down firm. Enough was then thrown into fill over the pipe to a depth of about 6 in., and this was tamped down carefully. The trench was then filled by team work. As this upper filling was left comparatively loose, considerable settling has occurred, and we have had to go over the lines again in most cases. With us this was not a serious matter, as there was no paving to suffer. Had there been, more care would have been taken with the fill.

The system as completed contains 40,506 ft. of main and lateral sewers, 1816 ft. of sub-drain, 6500 ft. of service branches, 74 manholes, 33 lamp or inspection holes, one submerged creek crossing, including the manholes at each end; 3 overhead crossings of steel pipe, 16 flush valves, and 1 sedimentation tank. The total yardage excavated in the main trenches and manholes was 14,234.5, at a cost of $3556.15, or an average unit cost of 24.98c. per cubic yard. This is a cost of 8.78c. per lineal foot of trench. The cost of trimming trench and laying the pipe was 2.12c. per foot. Unloading pipe from which to compute costs, the cost of an average of 65c. per foot, running as low as 40c. per foot. As it was not possible to get the pipe placed at all times just where it was wanted, there was a further cost for re-distribution which cannot be determined, but which probably brought the cost up to approximately 80c. per foot.

Owing to the lack of accurate records from which to compute costs, the cost of back-filling can only be estimated from the meagre data at hand. It appears to have been about 1.38c. per lineal foot of trench.

The cost of foremen, engineering force, supervision, and office records was 4.14c. per lineal foot of trench. Our manhole costs averaged $34.50 each, or 6.55c. per lineal foot of trench.

Ground was broken on April 10 for the tank excavation, trenching for sewers began on the 12th, and pipe-laying on the 13th. The tank was completed on May 8, and work on the manholes began the next day. The main trenches were finished on June 29, the manholes on July 3, and the construction period proper ended on July 13. The service branches were not all in, but as we had installed as many as there was an immediate call for, it was thought best to discharge all but three or four men and put in the branches as they were needed.

The engineering included not only all surveys and supervision, the preparing of all plans and estimates, but also the entire work of preparing the assessment rolls, involving a separate plat of each block included in the system with the location of

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the adjacent sewer and the valution of each holding marked thereon, and before final adoption this roll and the plats had to be revised three separate times.

The entire cost of the system up to this time was $22,131.42, as itemized below:

Engineering:	
Consulting engineers	$ 399.80
Instrument man, and rodman on preliminary	283.25
Office force	100.25
City engineer	829.00
Total	$1612.75

DETAIL OF COSTS

Engineering	$ 1,612.75
Labor, including foremen	10,191.41
Materials	8,587.91
Tools	365.13
Printing and stationery	237.75
Legal work	40.90
Industrial insurance	369.57
Rights-of-way	735.00
Total	$22,131.42

As the entire cost of the system was paid by a bond issue, and as no bonds could be issued until after the final cost had been determined very closely, the financing of the project had to be done by issuing interest-bearing warrants, which were taken up by the local bank at par.

The interest cost was approximately $400, in addition to the above items. Much minor detail work remained to be completed, such as bond issue costs, installation of flush valves, a thorough cleaning of the interior of all sewer lines, the completion of the branches, attention to the settling of trench back-fill, etc., some of which work is still in progress and is being cared for out of the sewer maintenance and extension fund. The probable ultimate cost of the system will be between $24,000 and $25,000, or about 50c. per lineal foot, including all expenses connected with its installation. It is also a cost of $16 per capita of present population served. This cannot be considered as an exorbitant cost when it is seen that the area served is 260 acres and the density of population is only 5.75 per acre.

The unit costs of materials were higher than usually obtain, owing to our isolated location and the consequent high transportation cost, but so far as accurate unit costs of labor could be ascertained, they were lower in comparison with the wage scale than any I have seen published.

Road Drag*

By E. F. AYRES

WHEREVER the highways are built of clay or other heavy soils, they may be maintained at slight expense by the use of the drag. The supervisor alone cannot get the best results from this implement; each one must look out for the road in front of his own property. More depends on the time the road is dragged than on any other one consideration, and only by taking short stretches can the work be done when the soil is in proper condition.

The success of the split log and plank drag has led to the introduction of patented machines. Most of these are built of steel, some of them being so heavy as to be practically wheelless graders. All of them are excellent for filling ruts and crowning the road, and the heavier ones are particularly serviceable for spreading gravel. The theory of the drag, however, is that it deposits a thin layer of puddled clay over the surface. When this dries it leaves a waterproof layer the full width of the drag; and while this will break through easily, enough films are formed in time to sustain traffic. The heavier drags move too much material at one time, the clay does not puddle well, and the layer never dries satisfactorily.

The first road drag was built from a split log by D. Ward King, a Missouri farmer. The split log has certain advantages, but unless one has had considerable experience with an axe it will probably be as well to use planks. The illustration shows a drag built from 2 to 3-in. planks, braced with 2 by 6-in. pieces spiked to the inner sides.

*Abstract from Bulletin 67, Oregon Agricultural College.

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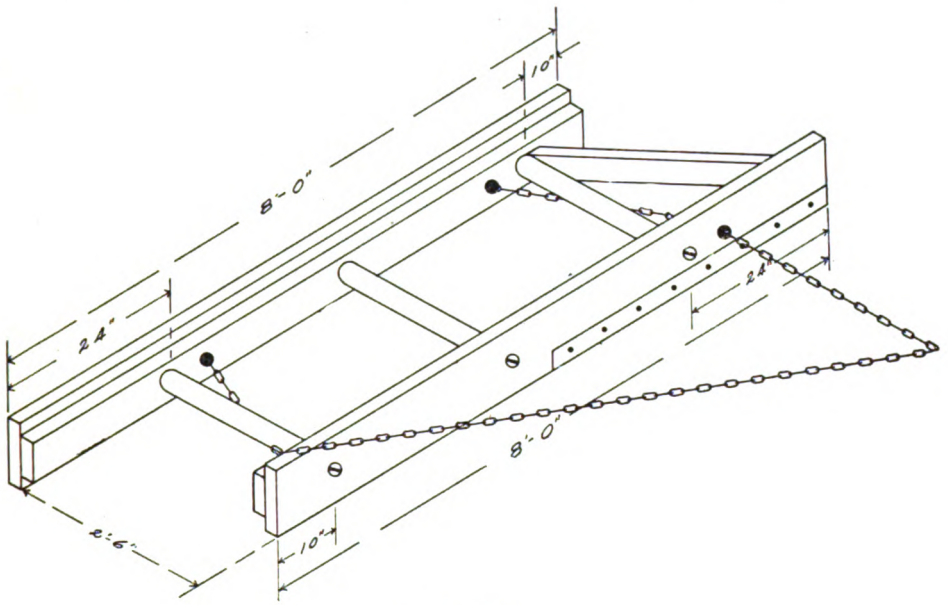
The cross-braces are made from 4-in. pieces shaped to fit a 2-in. hole. These should be split and wedged into place. The ditch end is braced with a piece of 2 by 4. A piece of iron about 3 in. wide is bolted to the ditch end of the front plank, extending half the length of the drag.

The holes for the cross-pieces are bored 10 in. and 24 in., respectively, from the ends of the planks, so that these will track when the drag is hauled at the proper angle. The hauling chain should be arranged so that the hitch may easily be adjusted, and the end nearest the centre of the road should be passed over rather than through the front plank. This allows the earth to slide easily along the face of the drag. A platform of 1-in. boards is laid on top of the cross-braces.

The drag should be used soon after a rain. Wait until the ground has lost its stickiness, when the material will slide easily along the face of the drag; but do not wait until the road is dry in any place. Dragging a dry road simply breaks up the layers formed in previous operations and actually injures the highway. Very little improvement will be noticed after the first trial; some of the ruts will be filled and some bumps may be slightly cut down. But after a few trials the benefits will become more apparent. It is perfectly true that anyone can use the drag, but the skill to get the best results will come only with practice. If you can manage to keep your feet on the platform during the first trip you are doing better than the average novice.

The following points should be remembered in the construction and the use of the drag:

Build a light drag, one that you can lift if necessary. Any drag that requires more than two horses is too heavy and should be discarded or used only on gravel roads.



A ROAD DRAG.

Hitch so that the drag will travel at an angle of 45° with the centre line of the road, and do not try to cut too much material at one operation. The amount moved depends wholly upon the length of hitch and the position of the driver. A long hitch will move more earth than a short one. When a hard spot must be cut, the driver throws all his weight on the front plank; when a soft spot must be filled, he moves back. If the crown gets too high, reverse the drag and move some of the material toward the ditches, taking care to smooth it down well. Until they have been dragged for some time few of our country roads are apt to get too much crown.

Drive the team at a walk and ride the

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entire distance. Drive up one wheel track and back the other. Do not try to improve too wide a section at one operation. Do not build too long a machine. For narrow roads the drag should be half the width of the traveled way, and a 9 or 10-ft. drag is long enough for any highway. Do not attempt to maintain too long a section. So much depends on the time the machine is used that there is danger of dragging the road when too wet at one end and too dry at the other.

Remember, the drag is only good in clay or similar soils. A sand road will not be benefited in the least, and if the drag is used to form a crown, the results will be positively harmful. A sand road needs all the moisture it can hold, and the crown drains this away.

The cost of maintaining earth roads with the drag is nominal. Few farms would have to purchase any of the material for its construction, although the district could easily afford to furnish lumber to all who would agree to build and use one. Roads in the Middle West have been dragged as cheaply as $2.50 per mile per year, and the highest cost was under $10 per mile. Assuming that the roads of Oregon would cost $10, the districts would still have sufficient funds available for new culverts and other permanent improvements. Many men would be willing to donate their time; but even where the district pays all the bills, the saving would be decidedly worth while.

A well dragged road will be free from mud and ruts in winter, and comparatively free from dust in the summer. The tractive force required to haul a load over it is as low as over the gravel, and in most cases no further improvement will be required until it needs macadam.

Cost Keeping at Panama*

COST KEEPING in connection with the construction and engineering work on the Panama canal has the threefold object of informing the chief engineer each month regarding: (1) the cost of work compared with the estimates made in December 1908; (2) the cost of work of a similar nature on two or more parts of the canal; (3) the costs of similar pieces of work from month to month on the same part of the canal. No attempt is made to keep so minute a record as would be kept on similar work in the United States, because this would involve an elaborate and costly system, and when the data were compiled they would not be comparable with data for similar work in any other part of the world.

The results of the cost keeping have been to keep alive the spirit of emulation that exists among the various divisions, encourage close supervision by indicating to men in responsible positions where and how economies may be effected, and generally to promote the spirit of economy by emphasizing the question of costs.

Returns from the cost keeping are placed before the chief engineer each month, and careful comparisons are made. If it is found that the costs of excavation, masonry, dams, machinery erection, or other classes of work are excessive in one part of the canal relative to similar work on another part, or in one month relative to the cost of work in previous months, the responsible official is so informed in order that he may make due explanation or take steps to remedy the situation.

The present cost system dates from January 1, 1910, and was evolved from a system begun on July 1, 1907. For administrative purposes, the costs are compiled by an accountant in the office of each division engineer, and sent thence to the cost keeping accountant in the office of the chief engineer at Culebra, where they are checked and compiled for publication.

There are three main sources of expense: labor, materials, and administration. The foremen on the work keep track of the distribution of labor in two sets of books, one for odd days and one for even days. Each night the books used that day are sent to the division offices and are looked over carefully by the supervisors of the work and by the cost accountant before they are again sent into the field. In this way they are kept in perfect order. At the end of each month the amount of labor that went into

*Abstract from *Canal Record*, February 19, 1913.

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each job and class of work is determined. This method is applied only where the variety of work requires it. In the Central division, where all the work is dry excavation, the labor charges are taken from the time-rolls and from the daily reports of the men in charge of equipment.

Material costs are determined by a system of foreman's orders kept in triplicate, by which materials drawn from stores are reported by the storekeepers of the quartermaster's department, and by them to the division offices. The costs are charged each day by the division cost accountant to the various classes of work, and at the end of each month these must agree with reports sent to the cost keeping accountant in the chief engineer's office by the storekeepers of the quartermaster's department. A similar system is used in accounting for materials drawn for the shops.

The arbitrary charge for plant and equipment on each part of the work is based upon the cost of the plant and the amount of work it must accomplish, as determined by the estimates of 1908. It was estimated at that time, for instance, that the plant for handling concrete at Miraflores locks would cost $674,651.13, and that the concrete to be placed would amount to 1,503,570 cu. yd. The plant arbitrary added to every cubic yard of concrete produced by this plant is enough to represent the proportion of the plant cost that each yard should bear. Every six months this arbitrary is adjusted on the basis of work performed and to be done. In this way the cost of the plant will be absorbed by the time the work is accomplished. This method of determining arbitraries is employed throughout the department of construction and engineering.

Overhead charges are determined in each division by the cost accountants. The general administrative expenses are prorated to the construction divisions on the basis of total expenditures, except where they can be definitely charged to the work. Other miscellaneous general expenses are prorated as nearly as possible on the basis of the benefits received by each division.

Excavation is one class of work carried on in all divisions, and is one of the simplest from the cost-keeping standpoint. The work is divided into its various parts, and careful track is kept in the field of the work and materials devoted to each part. This classification is shown in the following statement of costs of dry excavation in the Central division for the quarter ended December 31, 1912:

Classification.	Oct.	Nov.	Dec.	Total.
Quantities, cubic yards	1,113,420	973,071	1,074,510	3,161,001
Clearing	.....	.....	.....	.....
Drilling	$0.0657	$0.0691	$0.0601	$0.0648
Blasting	0.0514	0.0532	0.0534	0.0526
Loading	0.0550	0.0566	0.0529	0.0548
Tracks	0.0912	0.1005	0.0959	0.0957
Transportation	0.1015	0.0879	0.0806	0.0902
Dumps	0.0507	0.0697	0.0632	0.0608
Pumps	0.0085	0.0126	0.0057	0.0088
Maintenance of equipment	0.1075	0.1277	0.1118	0.1152
Plant arbitrary	.....	.....	.....	.....
Division expense	0.0140	0.0142	0.0114	0.0132
Total division cost	0.5455	0.5915	0.5350	0.5561
Administration and general expenses	0.0186	0.0400	0.0372	0.0315
Total cost	$0.5641	$0.6315	$0.5722	$0.5876

Each of these groups or classes is subdivided into 'operation' and 'repairs,' and each of these according to the elements that enter into the cost. In December the subdivision was as follows:

Drilling—Labor, shop expense, material and supplies, power, repairs. Repairs are again subdivided into labor, shop expense, and material and supplies.

Blasting—Labor, shop expense, material and supplies, explosives, including freight and handling.

Transportation — Labor, coal (including freight and handling), material and supplies, hostling, repairs to locomotives, cars, and cranes.

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Dumps—Labor, shop expense, material and supplies, repairs.

Tracks—Labor, shop expense, material and supplies, repairs and equipment.

Drainage and Sumps—Labor, shop expense, material and supplies.

Loading and maintenance of equipment costs are compiled from the items reported above, and do not form a separate class in the reports of the division engineers.

No clearing and no plant arbitrary are charged. The clearing for excavation in Culebra cut is finished; and the plant arbitrary assigned to this work has been absorbed, because it was based on an estimate in 1908 of 87,644,493 cu. yd., which amount, due to the slides in Culebra cut, has already been exceeded.

Elements entering into the varying costs of classes from month to month do not appear in the printed cost statement, but form part of the reports of the division engineers. One of the largest and most variable items is transportation, which was $0.1015 per cubic yard in October, $0.0879 in November, and $0.0806 in December. The amount of material handled and the rainfall, which was greater in October than in the other months, are unclassified elements in the greater cost; the more tangible elements are the following:

Cost per Cubic Yard of Dry Excavation

	Central Division.	Pacific Division.
Excavation, cu. yd.	3,161,001	759,985
Drilling	$0.0648	$0.0862
Blasting	0.0526	0.0159
Loading	0.0548	0.0941
Tracks	0.0957	0.2008
Transportation	0.0902	0.0969
Dumps	0.0608	0.0173
Pumps	0.0088	0.0309
Maintenance of equipment	0.1152	0.0873
Plant arbitrary	.....	0.0701
Division expense	0.0132	0.0276
Total division	0.5561	0.7271
Administration and general expense	0.0315	0.0557
Total cost	$0.5876	$0.7828

Dry excavation in the Pacific division is confined to two small sections, the channel between Pedro Miguel and Miraflores locks, and the channel below Miraflores locks. The space is restricted, the moving of tracks is constant, and the shifting of steam-shovels is frequent.

The cost of blasting per yard is small in the Pacific division because most of the material does not require blasting; the cost of loading is high because of the restricted area of work making constant shifting of cars necessary; the cost of tracks is high because they must be shifted continually; the cost of dumps is low because most of the material is used as filling, when the expense of dumping is charged to the cost of filling; the plant arbitrary forms part of the cost because the amount of excavation estimated in 1908, upon which the arbitrary charge is based, has not yet been exceeded.

Gross Cost of Operating Trains

	December.	November.	October.
Labor	$ 97,910.76	$ 99,065.55	$101,219.15
Coal	43,863.93	40,711.60	44,582.84
Material and supplies	2,622.82	2,428.43	14,062.09
Hoisting	4,924.40	5,409.26	5,364.20
Repairs to locomotives	36,503.97	32,170.91	34,224.96
Repairs to cars, wood	36,583.42	37,429.02	38,976.14
Repairs to cars, steel	10,684.67	11,427.43	12,148.71
Repairs to cranes, wrecking	251.88	2.38	17.79
Miscellaneous	.....	.....	122.02
Total	$233,345.85	$228,644.58	$250,717.90

All the classes are susceptible of analysis in the above manner, and it is this dividing of each part of work into its components that makes the cost-keeping system of value in supervision.

A comparison of similar classes of work in different divisions, as affected by local conditions, is afforded by the cost of dry excavation in the Central and Pacific divisions for the last quarter of 1912:

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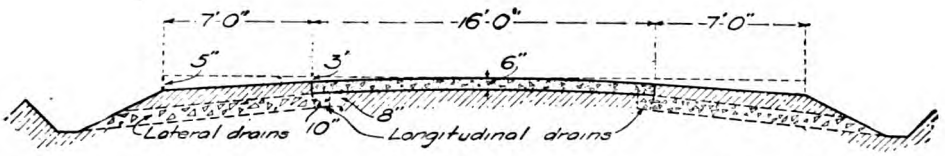
Carlinville Concrete Road Cost Data*

By A. N. JOHNSON†

THE Burke Lane improvement began at the western edge of the C. & A. railway right of way at Carlinville and extended along what is known as Burke's lane for a distance of 3000 ft. The soil is a black loam, and the road was fairly level but thickly shaded, and had been one of the worst roads in the community on that account. It had been filled in places with stone, brick, and cinders, making what little excavation had to be done rather expensive. The improvement consisted of a concrete roadway 16 ft. wide and 6½ in. thick. Crushed stone for the concrete was furnished from the southern Illinois penitentiary and sand was hauled from a creek west of Carlinville. The method of construction was as follows:

The roadbed was shaped to a proper grade, which was so firmly compacted that rolling was not necessary. As soon as the roadbed had been shaped, the sand and stone were hauled upon it in such quantities as would just make the concrete required. Prior to hauling the materials, the concrete machine was placed at the far end of the road. Along either side, boards 2 by 6 in. were set on edge, with their tops adjusted carefully to the proper elevation. Water for the concrete mixer was supplied by a temporary pipe laid alongside the road, in which were openings about every 250 ft., to which hose could be attached, the water in this case being obtained from the city supply at Carlinville. The concrete was mixed in proportion of 1:2:3½. As fast as the concrete was mixed and dumped upon the roadbed, it was shaped by a template, moved along the side forms as a guide. The finishers, working from a light bridge laid across the road, removed any imperfections in the surface which was, after a few hours, marked crossways with a heavy stable broom. As soon as could be done, a canvas was laid across the concrete and kept wet and the next day the surface was covered with earth which was thoroughly wet and kept in a moist condition for about two weeks.

An important feature of the work consisted in constructing under the edge of the concrete a longitudinal ditch about 6 or 8 in. deep, which was filled with crushed stone. From these ditches running under each edge of the concrete there extended laterally stone-filled trenches to the side ditches, these lateral drains being constructed in such a way that the water would drain from the roadbed to the side ditches. The object of these lateral drains is to prevent seepage, beneath the edge of the concrete at the shoulders, of water falling upon the concrete road.



CROSS-SECTION CARLINVILLE, ILLINOIS, CONCRETE ROAD.

From the C. & A. tracks for a distance of about 800 ft. westerly there was a newly constructed sewer trench. As the material in this trench had not had time to settle, the concrete road, where it spanned this trench and the lateral sewers leading from it, was reinforced with ½-in. twisted bars 6 ft. long spaced 12 in. apart.

Expansion joints were placed every 50 ft. and consisted in part of wood paving blocks and in part of steel plates manufactured for this purpose. The spaces between the plates were filled with tar paper. The joints were not placed at right angles with the line of the road, but at about 60°, the object being to afford the least possible inconvenience to traffic due to any unevenness that might exist at the joints.

*Abstract from *Concrete-Cement Age*, March 1913.
†Illinois State Highway Engineer.

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The expense for the improvement was paid from a special fund raised by subscription by a committee of citizens representing property along the road.

The following table is an itemized statement ot the cost of the road:

Amount of pavement laid	7,111 sq. yd.
Thickness of pavement	6½ in.
Width of pavement	16 ft.
Length of haul for material:	
Sand	1½ miles
Stone	1½ miles
Cost of cement per bbl. f.o.b. Carlinville	$0.98
Amount of cement used per sq. yd. of pavement	0.33 bbl.

Cost of Labor and Supplies

Superintendence	$ 157.50
Excavation	591.73
Shaping roadbed	108.70
Loading and hauling sand and stone, including rehandling	795.05
Mixing and placing concrete	700.58
Watchman and miscellaneous labor.	131.46
Cost of sand and stone f.o.b. (stone freight only, sand free)	741.00
Cost of cement f.o.b. Carlinville	2,307.90
Expansion joints	112.40
Reinforcing steel	100.00
Coal and oil for mixer and miscellaneous supplies	25.00
Forms and other lumber	31.75
Total	$5,803.07

Cost per Square Yard for Labor and Supplies

Superintendence	$0.0220
Excavation	0.0840
Shaping roadbed	0.0153
Loading and hauling stone and sand, including rehandling	0.1120
Mixing and placing concrete	0.0986
Watchman and miscellaneous labor..	0.0184
Cost of sand and stone f.o.b. (sand free at pit)	0.1050
Cost of cement f.o.b. Carlinville	0.3246
Expansion joints	0.1560
Reinforcing steel	0.0140
Coal and oil for mixer and miscellaneous supplies	0.0034
Forms and other lumber	0.0047
Total	$0.8176

Paint as an Engineering Material*

By MAXIMILIAN TOCH

THE progress that paint chemistry has made since 1905 is by far greater than the progress that was made from its earliest invention up to that date. It is very difficult for me to imagine that my first book, 'The Chemistry of Paints,' stimulated others to continue the work which I had started, and if the little that I have done to enlighten the manufacturers and consumers has brought about the progressive results, I certainly have been rewarded for all the work I have ever done on the subject.

The first 'skyscraper' ever built in New York was the Gillender building, corner of Wall and Nassau streets, which was razed two years ago. Chemists knew before this building was demolished that linseed oil paint was not the best material for the protection of the steel of large buildings. The question as to whether monumental buildings are permanent has been a source of great worry to many chemists and engineers. Fortunately, if any of the steel contained in buildings like the Woolworth building, Metropolitan tower, the Singer tower, and dozens of others should show signs of corrosion and disintegration, the process is so slow that preventive methods could be applied, for a beam could not corrode in a masonry wall without cracking or bulging the wall. I have in mind one building in Maiden Lane where this actually occurred; the wall of the fifteenth floor was cut away, the corroded beam exposed, thoroughly scraped, painted, and reinforced, surrounded by con-

*Abstracted by the author from an address presented before the New York Section of the American Chemical Society, Chemists' Club, February 7, 1913, and published in the *Journal of Industrial and Engineering Chemistry*.

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crete, and the brick wall replaced.

From the street-level up, every skyscraper in the world is safe, but from the street-level to the grillage beams is the dangerous point. Of course, a small building could be jacked up and a grillage beam replaced. In large buildings—two of which I have in mind—where the grillages were affected by leaky electrical currents, the foundation beams were uncovered, scraped clean, and painted, and then a grout of almost pure neat cement injected all over the surface. Of course, it would be out of the question to jack up a building like the Woolworth building, or the Metropolitan Life, even though Archimedes said, "Give me a fulcrum and I will move the world"; but it is a source of great satisfaction to know that engineers and architects in charge of these buildings have taken sufficient precautions to prevent any danger whatever, either from electrolysis by means of stray currents, or from corrosion by means of dampness. All the sensational talk about the danger of the newer skyscrapers not lasting fifty years is utter rot, for every one of these buildings is so constructed that should any danger result it could be remedied in due time.

That paint is an engineering material of incalculable value is evidenced by the fact that bridges would not last ten years if they were not repeatedly painted and watched. The railroads are much wider awake to this condition than the municipal governments. Politics and paint do not mix very well, as is evidenced by the condition of some municipal bridges. It may be safely said that the elevated railroads in New York City and all of the battleships of the United States Government depend for their life on the frequency with which they are painted. My examination of the battleship *Maine* when the wreck was uncovered last year showed that not a vestige of paint remained, and it furthermore showed that wherever steel and copper, or iron and bronze, were in close proximity an electric battery was formed, and the iron was completely dissolved.

The aphorism "cement protects steel permanently against corrosion" needs some little explanation. Unfortunately this saying is true and correct, and, still more unfortunately, there is no such thing in building construction as cement. I know that this sounds ridiculous in view of the fact that in 1912 upward of 60,000,000 barrels of cement was used in concrete construction, and a large part of it was used in reinforced concrete construction, which means that steel rods were embedded in it. But you must bear in mind that cement is never used as such in any kind of construction, only a mixture of cement, sand, and broken stone is used; the average amount of cement contained in most engineering operations is 15, so that when people talk about cement being used they really mean concrete, which under many circumstances is a nondescript mixture. It is a trifle out of place for me to go into the reasons why cement is not used, and one or two examples will suffice to indicate why concrete is used. Cement is entirely too rich and entirely too expensive to use by itself; the sand and other ingredients which are added to cement can never under any circumstances be classed as adulterants, particularly sand, because when a cement grout is used that is too rich it will crack or craze, as the case may be. If you were to drive a tack with a 10-lb. sledge-hammer, you would undoubtedly accomplish the object, but you might possibly destroy or break the material into which the tack was driven. But if you use a little 2-oz. hammer you accomplish the result better and without any ill effects. The same comparison holds true as to the use of aggregate in cement. The dilution of the cement with inert material saves money and gives better engineering results, but yet, when 85% of material which may be cinders, broken stone, or sandy material containing more or less soluble salts is added, and when the workmanship is taken into consideration, and voids are produced, it is quite obvious that rust may start in concrete, and the small percentage of cement will be insufficient to overcome or check the oxidation. There is a wall in New York City which shows this fact markedly, and in a wall of this type an insulating paint or insulating material would have prevented the oxidation of the steel and the subsequent cracking of the wall.

This then leads me to the general subject of the more modern type of paint, containing no saponifiable oil, but made entirely of such materials as are unaffected by alkali. Such tremendous structures as the Pennsylvania Terminal in New York, and Metropolitan Life tower and building,

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the Woolworth building, and the newest and largest of all engineering structures, the New York & Connecting railway—not yet finished—are types of modern structures in which the old-time linseed-oil paints have been superseded, the steel being protected by more scientific paints. Perhaps the most remarkable fact in all these instances is that about fifteen years ago, one concern in the United States started a campaign of education and convinced many prominent and well known engineers that paint was an engineering material and that no one material is suitable for all purposes, with the result that the paint industry has been raised from empiricism to an exact science. Ten years ago nobody dreamed of painting cement floors or cement walls, on account of the tradition that it was impossible to paint concrete. It is quite true that it is impossible to paint new concrete with a linseed oil paint, owing to the resulting chemical reaction of the combination of the oil and the lime in the concrete. When the first patent was taken out on this subject, nobody infringed because it was believed that it could not be a success, and after it was demonstrated that this was a success, it was the same story as Columbus and the egg, and everybody imitated and made a business of it.

The United States Navy, through one of its most efficient Naval Constructors, Henry Williams, has kept pace with the paint progress, and Mr. Williams' article, 'Newer Paint Conditions in the United States Navy,' read before the Eighth International Congress of Applied Chemistry, was copied not only by every paper in the United States, but was heralded throughout Europe. To those who want to know what excellent progress has been made in this branch of the Government work, I would refer to his excellent treatise on the subject, which is to be found in the transactions of the Eighth International Congress of Applied Chemistry.

Investigation of the Reclamation Service*

By F. K. LANE

GENTLEMEN, you all know why this conference is called. It is called primarily to educate me. I wanted to get you here. I wanted to hear directly from you the story of your adventure. I wanted to know whether that adventure was successful or not. I wanted you to help me in administering this great trust in the interest of all of us. Since I have been in this office and long before, the air has been filled with criticism and complaint. How much of it is well founded, I do not know, and possibly no one of you can tell. Therefore I thought it best, in the interest of this great service, which is, on the whole, the most important work of a constructive character that our people have ever undertaken, that you should come face to face with those who have carried on those projects for you and for the Government; that you should have a full opportunity to succinctly, clearly, and specifically state the conditions of your project, and your state of mind, because I recognize that in all of these matters the state of mind is just as important as the state of the soil, and if you can get out of your systems those things that are not true, and if you can have me recognize precisely what is true and help me to do the right thing for you, a great service can be done our country.

There is no limit to this conference in point of time. I want to know all that is to be known. I want to know nothing whatever but fact. I want you to say nothing excepting those things that you can justify, and that you feel you can be responsible for. And do not hesitate to be in every way truthful. I mean by that not alone to say what you know to be so, but to say all that you know to be so. No man connected with any one of these projects will ever suffer, so long as I am here, by anything he says in this conference.

I regard myself here as the representative of the Government that has undertaken

*Remarks upon opening the conference between water users and department officials, Washington, May 1, by the Secretary of Interior.

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to do something on behalf of the American people, on behalf particularly of that portion of the country that we call the 'desert' —my country, your country, the land that lies beyond the Missouri, in great part. So I want you to be perfectly free, and I am going to have the proceedings and the program just as informal as possible and be consistent with order. I shall take up the projects one after another, and call whichever you may designate as representatives of the Water Users Association, or any other organization, or any independent man who represents no organization, but is familiar with the facts, to come forward and take this seat and tell me just what conditions are. Then he is to be subjected to interrogation by myself, by any representative of the Reclamation Service, by his senator or his congressmen, or any others of you who desire to speak or to bring out a fact.

This is not a mass-meeting; it is not a political convention. We are to have things done in order, so that there may be some result. Nobody, of course, will be sworn, because I assume that all will tell the truth. We will take up the states alphabetically and begin with Arizona. The first project there is the Salt River Valley Project, which is partly California, and then proceed through the states alphabetically.

Let me close by soliciting you earnestly to look at this thing as I must look at it, with a desire to improve this service and help me, if you can, to solve the troublesome problems that arise here. I know that I am a long way off from you. I have lived with some of you. I know your country. It is not necessary, therefore, to give me a new standpoint, but it is necessary to give me your own feeling and the facts that you have.

Riverbank Experimental Road*

AN experimental concrete road, 3000 ft. long and 18 ft. wide, was constructed last fall between Sacramento and Riverbank, California, passing through the Riverbank subdivision of the West Sacramento Company. The company has large holdings in this vicinity, in the development of which the road problem led it to experiment with ten various sections of concrete pavement to determine its applicability to local climatic, traffic, and sub-grade conditions. The engineers also wished to determine the most economical design. It is believed the comparatively uniform temperatures in California will minimize to a large extent expansion and contraction difficulties.

On the western half of the roadway the sub-grade material is a heavy clay loam soil, resembling an adobe. The eastern half of the slab was constructed over an old macadam roadway. The sub-grade was excavated and trimmed to the required grade and crown. It was then thoroughly compacted by sprinkling and rolling with an 8-ton roller. All portions of the old macadam road in fill were well tamped. In all cases the sub-grade was well moistened just previous to placing the concrete, to prevent abstraction of water from the concrete.

All work was given a crown by sloping the surface from the centre to each side of the roadway at the rate of ⅓ in. per foot. Local experience with other types of pavement has led to a standardization of this feature. Longitudinally, the roadway is practically level.

Four of the sections were reinforced with a light wire mesh having a cross-sectional area less than 0.1% of the area of the concrete. While this is sufficient to reinforce the slab against temperature and shrinkage stresses, it was thought that it might prove valuable in holding the road intact. Rectangular and triangular mesh reinforcement of the American Steel & Wire Co. and the Clinton Wire Cloth Co. was used.

Four types of expansion joints were experimented with. In the first, lines of oiled surfaces were spaced at 10, 20, 30, and 40-ft. intervals squarely and diagonally across the pavement. Tar-paper joints were laid 10 and 20 ft. apart on square and diagonal lines. In another section ¼-in. spaces were filled with bitumen at intervals of 25 and 40 ft. on square and diagonal lines transversely with the pavement. A fourth type

*Abstract from *Engineering Record*, March 8, 1913.

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consisted of ⅜-in. spaces at 30-ft. intervals, squarely across the pavement, with the edges protected by soft-steel plates 4 in. wide and held in place by anchor bolts. A section 217 ft. long was laid without expansion joints.

Various types of finished surface were used in an attempt to minimize the hard, slippery, inelastic, and glaring surface usually attributed to concrete. These included roughening with wire brooms, pitting by an embossed tamper, checkering and grooving with checks 6 in. square, plain concrete, sanding and covering the surface with a 3/16-in. coat of bitumen and Natomas rock screenings.

While 'Golden Gate' portland cement was used for the greater portion of the roadway, short strips were constructed with 'Mount Diablo' and 'Riverside' brands, all of which passed the standard tests prescribed by the American Society of Civil Engineers. Concrete was mixed in a ¾-yd. gasoline engine-driven Ransome mixer, on the sidewalk area

TABLE 1.—COMPARATIVE STRENGTH TESTS ON VARIOUS SANDS

Sample.	Sacramento river sand.	Yuba river sand.....	Natomas fine crush....	Standard Ottawa sand
Percentage of voids.	38.00	37.50	36.00	...
Specific gravity	2.65	2.66	2.82	...
Tensile strength 1:3 mortar, lb.	61	111	306	225
Tensile strength 1:2 mortar, lb.	290	404	594	475

TABLE 2.—PROPERTIES OF MIXTURES USED IN EXPERIMENTAL ROADWAY

Mixtures of sand, fine and coarse aggregate.	Fine aggregate.				Coarse aggregate of crushed rock.		
	Sac. river sand..	Screenings, parts	Yuba river sand, parts	Excess of cement over voids, %....	1½ to ¾ inches, parts	¾ to ⅜ inch, parts	Excess of mortar over voids, %....
1:1.6:5	1.60	...	...	119.0	...	5.00	15.3
1:1.8:4	1.80	...	...	96.0	4.00	0.80	34.4
1:2:4½ (a)	2.00	...	...	76.5	4.50	0.90	30.3
1:2:4½ (b)	2.00	...	...	76.5	4.50	1.15	34.0
1:2:5	2.00	...	...	76.5	5.00	1.25	16.6
1:2:5¼	2.00	...	...	76.5	...	5.25	31.0
1:2:6	2.00	...	...	76.5	6.00	1.50	...
1:2¼:3¾	2.25	...	...	56.5	3.75	0.75	68.4
1:2½:5	2.50	...	...	40.6	5.00	1.25	41.2
1:2½:5½ (a)	2.50	...	...	40.6	5.50	1.40	28.0
1:2½:5½ (b)	1.66	1.66	...	38.4	5.50	1.40	28.0
1:2½:6 (a)	2.50	0.62	...	38.4	6.00	1.50	17.6
1:2½:6 (b)	1.66	1.66	...	38.4	6.00	1.50	17.6
1:2½:6 (c)	2.18	0.73	...	40.6	6.00	1.50	17.6
1:2½:6 (d)	...	...	2.50	34.3	6.00	1.50	34.8
1:3:4.55	...	3.00	0.75	1.0	4.55	1.14	78.0
1:3:5½	...	...	3.00	...	5.50	1.37	47.0
1:3:6	...	...	3.00	...	6.00	1.50	34.8
1:3:7	...	...	3.00	...	7.00	1.75	16.0

In determining the per cent excess of cement over voids in the fine aggregate and of mortar over voids in a coarse aggregate the volumes and voids were measured for packed masses.

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TABLE 3—COMBINATIONS IN VARIOUS SECTIONS OF EXPERIMENTAL ROADWAY

Section No.	Length in ft.	Thickness, in.	Mixture.	Reinforcement.	Surface.	Expansion joint.
0	600	6	1:2:5	None.	Grooved with tampers.	Oiled paper and oiled surface.
1	200	6	1:2½:6	None.	Sanded.	Oiled surface, ¼-in. spaces filled with bitumen and screenings.
2	200	6	1:3:6	No. 12 rectangular wire mesh.	Concrete surface plain; roadway surface ⅜-in. bitumen and screenings.	¼-in. spaces filled with bitumen and screenings.
3	300	6	1:2½:5½	None.	Concrete surface plain; roadway surface ⅜-in. bitumen and screenings.	¼-in. spaces filled with bitumen and screenings.
4	275	6	1:2½:6	None.	Plain.	Diagonal joints, single thickness tarred paper and oiled surface.
5	247	4	1:2:4	No. 7 tringular mesh.	Roughened with embossed tampers.	Oiled surface.
6	250	4	1:2:4½	None.	Broomed.	Easterly 120 ft., one thickness of tarred paper and oiled surface.
7	250	6	1:2:5	None.	Roughened with embossed tampers.	Oiled surface.
8	260	5	1:2½:6	No. 7 tringular mesh.	Broomed.	Double thickness tarred paper.
9	270	5	1:2½:5	None.	Roughened with embossed tampers.	⅜-in. spaces at 30 ft. protected by soft iron plate.
10	217	4	1:2:5¼	No. 12 rectangular wire mesh, except 20 ft. on east end.	Checkered with grooves.	None.

alongside the road, and wheeled to place in 10-cu. ft. buggies. At each position of the mixer approximately 300 ft. road was constructed.

Three classes of fine aggregate were used: (1) Sacramento river sand, dredged near the site of the work, having very fine, much-rounded quartz grains; it contains a considerable proportion of mica plates, but very little sediment. (2) Yuba river sand, dredged from the Yuba river at Marysville, having medium-sized quartz grains, somewhat rounded; it contains little mica, but small amounts of sediment and small balls of mud. (3) Natomas fine-crushed rock, varying from ⅜ in. to dust. It is very sharp and carries so much fine stonedust that it is difficult to determine the percentage by sedimentation.

Tests were made of the three classes of fine aggregate, and for comparative purposes strength tests were made on Ottawa sand. Voids were determined by thoroughly compacting 100 c.c. of dry sand, then adding 100 c.c. of water and reading the amount absorbed by the sand. Briquettes were made of standard Ottawa sand and cement, as well as of the materials to be tested. The quantity of water, however, was varied in order to get a mortar in each case as nearly as possible with the same consistence as that made from the standard sand. As compared with the standard sand, there was required for the Sacramento river sand nearly double the amount of water, for the Yuba river sand 50% more water, and for the Natomas fine crush about the same quantity. Tensile tests were made after 7 days. It will be noted that the Natomas fine crush made a considerably stronger mortar than the standard Ottawa sand. The results are given in Table 1.

In all cases, the coarse aggregate was material obtained by crushing the tailing from the gold-dredgings in the vicinity of Folsom. The dredgings vary from pebbles the size of an egg to boulders a foot or more in diameter, composed of a hard and tough altered andesite. As placed on the market, the rock is in four sizes, 2½ to 1½ in., 1½ to ¾ in., ¾ to ⅜ in.; screenings, ⅜ in. to dust. Only the last three sizes were put into the road concrete. The percentage of voids in the 1½ to ¾-in. size ranged from 46.7 to 48.5 loose; the ¾ to ⅜-in. size ranged from 43.3 to 39.7. By mix-

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ing these two sizes in various proportions the voids were reduced to about 40 per cent.

With the object of obtaining a dense concrete with a minimum amount of cement, careful tests of the voids in the various materials were made by weighing the water filling the interstices in a cubic-foot box. Tests for determining the relative proportions of the different materials which would make the densest aggregate were also made by thoroughly mixing the dry materials loose. This was accomplished by shaking and rolling the various mixtures in a large canvas and weighing 1 cu. ft. of the material to determine which mixture had the greatest weight per unit volume and hence the smallest proportion of voids.

Messrs. Haviland, Dozier, and Tibbetts, consulting engineers, of San Francisco and Sacramento, had charge of the design and construction. They were represented in the field by Paul Bailey, resident engineer, who did the work by force account for the West Sacramento Company.

Cost of Machine Concrete Mixing Compared With Hand Mixing.*

By C. H. HUBBELL

THE municipal contractor who starts in on a big job with the hand mixing method and later adopts improved machinery for mixing, readily appreciates the saving effected.

We spent the summer of 1911 and 1912 on a concrete pavement job at Davenport, Iowa, using the hand mixing method in 1911 and improved machine mixing in 1912, enabling us to make the following comparisons:

	Hand mixing, cu. yd.	Machine mixing, cu. yd.
Av. yardage per man on street pavement (except watchman, water, and sack boys)	2.31	3.83
Av. yardage per man on street pavement (including all engaged in the mixing operation)	3.04	4.788
Cost per cu. yd. of street pavement (including only wheelers, loaders, mixers, spreaders)	$0.64	$0.508
Cost per cu. yd. of street pavement (including all engaged in the mixing operation)	1.075	0.74

The machine responsible for the above savings, and which we are now operating, is a No. 14 Koehring special paving mixer, which has an average yardage of 200 per day with the following gang:

In front of machine—3 stone wheelers; 8 stone loaders (two loaders per barrow); 3 sand wheelers and loaders (two barrows); 1 cement wheeler (three sacks per load); 3 machine men (fireman, engineer, bucket man).

At rear of machine—2 spreaders; 1 tamper; 1 template setter and block placer; 2 finishers.

This street-paving machine renders unnecessary the barrow hauling of concrete, as it charges, mixes, and deposits automatically. The bucket travels on a 25-ft. boom, which swings through an angle of 170°. The hinge type skip has a capacity of 14 to 17 cu. ft. Our experience is that fuel burned runs from 3½ to 2 lb. of bituminous coal per square yard of pavement laid. This machine will easily ascend a 12% grade, and we run it along the work on plank sections 8 ft. in length. As a rule, we place our material directly on the ground, placing the sand and granite chips on one side and the stone piles on the opposite side of the road ahead of the machine. We place the sacks of cement on top of the stone piles and the granite chips in between the road piles.

Our skip charge for the wearing surface consists of 4 sacks cement, 3 barrows sand, 2 barrows granite chips.

The following calculations show the de-

*From *Municipal Engineering*.

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tailed labor costs of job A as well as summaries of the unit costs of jobs A, B, C, and D, of the work above referred to:

JOB A (3100 SQ. YD.).

Base 5 in. 1:3:5. Average output equals 530 sq. yd. Time, 5.7 hours.

		Total.	Per sq. yd.
9 men on rock	at 22½c.	$11.55	$0.0218
3 men on sand	at 22½c.	3.85	0.0073
1 man at skip	at 22½c.	1.28	0.0024
1 man wheeling cement	at 22½c.	1.28	0.0024
1 man leveling concrete	at 25c.	1.43	0.0027
1 helper leveling concrete	at 22½c.	1.28	0.0024
1 tamper	at 22½c.	1.28	0.0024
1 engineer	at 25c.	1.43	0.0027
1 fireman	at 25c.	1.43	0.0027
1 bucket operator	at 15c.	0.86	0.0016
1 water boy	at 5c.	0.28	0.0005
1 foreman	at 45c.	2.57	0.0048
Total		$28.80	$0.0543

Wearing surface, 1½c. 1:1:1. Average output, 530 sq. yd. Time, 2.8 hours.

		Total.	Per sq. yd.
4 men on granite chips	at 22½c.	$ 2.52	$0.0048
4 men on sand	at 22½c.	2.52	0.0048
2 men at skip	at 22½c.	1.26	0.0024
2 men wheeling cement	at 22½c.	1.26	0.0024
2 rough spreaders	at 22½c.	1.26	0.0024
1 fine spreader (also tamps top)	at 25c.	0.70	0.0013
1 fireman	at 25c.	0.70	0.0013
1 engineer	at 25c.	0.70	0.0013
1 bucket operator	at 15c.	0.42	0.0008
1 water boy	at 5c.	0.14	0.0002
1 sack boy	at 5c.	0.14	0.0002
1 foreman	at 45c.	1.26	0.0024
Total		$12.88	$0.0245
Finishing (530 sq. yd.)—			
1 finisher, 13 hr.	at 25c.	$3.25	$0.0061
1 helper, 13 hr.	at 22½c.	2.93	0.0055
Total		$6.18	$0.0116
Form-setter—			
1 man, 10 hr.	at 22½c.	$2.25	$0.0042
Miscellaneous—			
1 man trimming grade, 10 hr.		$2.25	$0.0043
2 men cleaning up stone, sand, etc., while top is being placed, 4.3 hr. each		1.49	0.0036
Total		$4.19	$0.0079

The time required for moving the machine was 15 hr. for eight moves. The wearing surface organization is charged with moving the machine; so to arrive at the cost, take 1.5/2.8 times $12.88, which equals $6.90. Unit cost equals $0.013 per square yard.

SUMMARY, JOB A

	Per sq. yd.	Per cu. yd.
Development expenses	$0.0090	$0.0500
Watchman	0.0050	0.0277
Base	0.0543	0.3008
Top	0.0245	0.1357
Finishing	0.0116	0.0643
Setting forms	0.0042	0.0233
Miscellaneous	0.0079	0.0438
Cleaning street, etc.	0.0055	0.0305
Moving machine	0.0130	0.0730
Total	$0.1350	$0.7481

The average output of 530 sq. yd. or 95.7 cu. yd. with this organization is conservative. With no delays of any sort, it could put in nine sections of 180 lin. ft. This is equivalent to 600 sq. yd. The greatest problem is to get sufficient raw material on the street. With 11 men on stone, an average of 600 sq. yd. can be placed, while a maximum of 670 sq. yd. has been attained. The cost of paving alley returns on a 30-ft. street was approximately 25% greater than the cost of paving the centre of the street. This was due to the necessity of shoveling concrete for a distance of 15 ft., since the boom reached only to the curb.

SUMMARY, JOB B (2300 SQ. YD.)

	Per sq. yd.
Development expenses	$0.0088
Watchman	0.0048
Base	0.0526
Top	0.0237
Finishing	0.0112
Form setting	0.0041
Miscellaneous	0.0071
Cleaning street, boulevard, etc.	0.0054
Moving machine	0.0125
Total	$0.1302

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Laborers' wages were 22½c. per hour, and conditions were almost identical with those of job A.

SUMMARY JOB C (3500 SQ. YD.)

	Per sq. yd.
Development expenses	$0.0185
Watchman	0.0060
Base	0.0595
Top	0.0268
Finishing	0.0122
Form setting	0.0047
Miscellaneous	0.0080
Cleaning street, etc.	0.0061
Moving machine	0.0141
Total	$0.1514

Laborers were paid 25c. per hour on this job. Delays were frequent, due to shortage of rock, sand, and men.

SUMMARY, JOB D (1600 SQ. YD.)

	Per sq. yd.
Development expenses	$0.0155
Watchman	0.0060
Base	0.0584
Top	0.0260
Finishing	0.0120
Form setting	0.0042
Miscellaneous	0.0080
Cleaning street	0.0041
Moving machine	0.0139
Total	$0.1472

Policy of Seattle in Relation to the Cedar River Watershed*

THE acquisition of lands in the Cedar river watershed by the city of Seattle, in connection with the construction of the Cedar river water-supply system and the municipal light and power plant, and for the purpose of protecting the water supply from pollution, was undertaken by the city about thirteen years ago, beginning in a small way and extending from year to year as time went on, until there is now owned by the city of Seattle, within the watershed, a total area of 37,982 acres, or 59.35 square miles.

The policy of the city in acquiring the lands within the watershed for the purpose of protecting its water supply is one, the wisdom of which has been demonstrated by the results obtained up to this time, and the continuation of this policy in the acquisition of the remainder of the land in the watershed will result in giving to the city of Seattle an assurance of a continuation of an adequate supply of pure and wholesome water not surpassed by that of any city in the world.

At the time the acquisition of these lands was first undertaken by the city there were within the lower watershed several sawmills and logging companies which had been operating there for a number of years. The city at that time had not sufficient money to undertake the purchase of the timber belonging to these mills and logging companies, or of the mills and equipment of the companies; and for that reason the operations of logging and cutting of timber have been carried on in this lower watershed by private parties up to the present time and are still being carried on in such manner. The city has been successful, however, in the regulation of these operations so that the danger to the water supply has been reduced to a minimum and the operation of the camp and of the mills has been carried on in a reasonably sanitary manner.

Within the upper watershed, however, extending from the site of the masonry dam at camp 2, including Cedar lake and reaching to the summit of the Cascade mountains, no logging operations had been commenced at the time of the establishment of the city's policy to acquire the land in the Cedar river watershed, and up to this time the city of Seattle has been successful in preventing the establishment of logging camps and sawmills in this territory. In order to prevent the establishment of these camps it has been necessary for the city to purchase, in many instances, not only the land but also the timber standing thereon. In this manner there has been acquired timber having

*From a 'Report on the Reforestation of the Lands in the Cedar River Watershed,' by R. H. Ober and H. C. Johnson, made to the Mayor, City Council, and Board of Public Works of Seattle, Washington.

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an estimated value at the present time of nearly $700,000. The total cost of the acquiring of all the land and timber in the watershed up to this time, exclusive of cost of surveys, appraisals and court costs, is something over $600,000, or nearly $100,000 less than the estimated cost of the timber alone. Adding the cost of survey, appraisals, timber cruising, and court costs, it is found that the value of the timber belonging to the city is approximately equal to the cost of acquiring both land and timber up to the present time.

If the established policy of the city, as approved by the voters in authorizing the issuance of bonds in the amount of $1,000,000 for the purpose of acquiring the land in the watershed, be continued by the city in the future in the acquisition of the remaining land and timber in the upper watershed, it should result finally in the obtaining of the entire watershed without material cost to the city. In other words, the increase in stumpage value of timber should be sufficient to pay for the cost of acquiring the land. In order to realize these values, however, it will be necessary, under proper sanitary regulations, to cut and market the timber. Upon the removal of this timber there arises the problem of determining the best use to be made of the logged-off lands.

The report covers in great detail the character of the watershed, the problems to be met, the methods available, and the estimates of cost. The tables of cost are especially valuable, as they have been reduced to unit costs under various conditions and methods. A large scale map accompanies the report.

Panama Canal Construction Expenditures to December 31, 1912*

Includes administrative and general expenses, but does not include 'General Items' or expenditures for sanitation, hospitals, or civil administration.

Items.	Total to December 31, 1912.		
	Quantities.	Amount.	Unit cost.
Atlantic division—			
1 Dry excavation, prism	2,181,998	$1,458,183.12	$0.6683
2 Hydraulic excavation, prism	29,605	11,671.32	0.3942
3 Dredging excavation, prism	32,197,473	7,637,184.31	0.2372
Gatun spillway—			
4 Dry excavation	1,544,202	$1,096,180.59	$0.7099
5 Preparing foundations	44,266	96,875.93	2.1885
6 Masonry	211,619	1,689,141.38	7.9820
7 Ironwork	.....	176,226.74	.....
8 Back filling	24,716	12,456.18	0.5400
9 Machinery	.....	68,834.23	.....
Total	.....	$3,139,715.05	.....
Gatun dam—			
10 Dredging excavation	38,425	$ 20,041.19	$0.5216
11 Dry filling	11,240,263	5,016,558.47	0.4463
12 Hydraulic filling	10,728,965	3,230,626.94	0.3011
13 Paving	.....	15,192.60	.....
Total	.....	$8,282,419.20	.....
Gatun locks—			
14 Dry excavation	4,555,395	$3,088,411.25	$0.6780
15 Dredging excavation	1,756,977	559,881.42	0.3187
16 Preparing foundations, excavation	216,881	413,170.89	1.9051
17 Preparing foundations, dredging	13,000	20,447.40	1.5729

*Abstract from *Canal Record*, February 19, 1913.

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Items.	Total to December 31, 1912. Quantities.	Amount.	Unit cost.
18 Preparing foundations, filling	40,117	$ 15,226.73	$0.3796
19 Preparing foundations, concrete piling, (lineal feet)	83,670	134,572.36	1.6084
20 Preparing foundations, wooden piling, (lineal feet)	92,670	70,182.45	0.7573
21 Filling around S. approach wall, dry	7,072	3,777.61	0.5342
22 Filling around S. approach wall, hydraulic	594,495	94,077.49	0.1582
23 Masonry	1,908,448	14,289,657.38	7.4876
24 Gates	.....	1,554,905.08	.....
25 Ironwork	.....	1,323,289.77	.....
26 Backfilling	1,828,114	944,167.20	0.5165
27 Filling centre wall	113,163	93,510.16	0.8263
28 Operating machinery	.....	1,611,473.94	.....
29 Emergency dams	.....	333,389.85	.....
Total	.....	$24,550,140.98	.....
Gatun power plant (permanent)—			
30 Dry excavation	87,067	$ 35,310.45	$0.4056
31 Preparing foundations	10,645	17,320.03	1.6271
32 Masonry	649	9,626.08	14.8322
33 Machinery	.....	182,802.65	.....
34 Transmission line	.....	37.73	.....
Total	.....	$ 245,096.94	.....
Gatun-Mindi Levee—			
35 Dry fill	177,158	$ 68,985.15	$0.3894
36 Hydraulic fill	20,398	3,483.32	0.1708
Total	.....	$ 72,468.47	.....
37 Clearing drift in Gatun lake	.....	3,156.99	.....
38 Colon breakwater	945,520	2,095,889.18	$2.1958
39 Terminal facilities—Cristobal	.....	4,924.98	.....
Total construction cost Atlantic division.	.....	$47,500,850.54	.....
40 Plant and equipment to be absorbed in construction costs after Dec. 31, 1912	.....	843,591.98	.....
Total expenditures, Atlantic division	.....	$48,344,442.52	.....
Central division—			
41 Dry excavation, prism	100,915,892	$80,048,078.12	$0.7932
42 Clearing canal line, without excavation, (acres)	2,280	141,426.75	62.0293
43 Dredging excavation	.....	9,798.40	.....
44 Masonry	1,271	8,353.66	6.5725
45 Masonry, cement gun facing (sq. yd.)	4,240	4,079.11	0.9598
Total construction cost, Central division.	.....	$80,211,736.04	.....
46 Plant and equipment to be absorbed in construction costs after Dec. 31, 1912	.....	*39,232.63	.....
Total expenditures, Central division	.....	$80,172,503.41	.....

*Denotes credit.

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Items.	Total to December 31, 1912. Quantities.	Amount.	Unit cost.
Pacific division—			
47 Dry excavation, prism	2,541,536	$2,056,688.82	$0.8092
48 Dredging excavation, prism	34,628,588	8,529,539.96	0.2463
49 Hydraulic excavation, prism	1,549,904	1,120,907.35	0.7232
Pedro Miguel dam—			
50 Masonry	937	$ 5,678.15	$6.0599
51 Dry excavation	10,171	19,403.19	1.9077
52 Dry filling	670,680	327,084.04	0.4877
Total	.....	$ 352,165.38	.....
Pedro Miguel locks—			
53 Dry excavation	1,133,280	$ 1,031,422.86	$0.9101
54 Preparing foundations	172,680	466,378.77	2.7008
55 Masonry	888,524	5,151,930.50	5.7983
56 Gates	.....	860,729.35	.....
57 Ironwork	.....	660,809.03	.....
58 Back-filling	704,205	289,762.25	0.4115
59 Filling centre wall	70,742	48,629.46	0.6874
60 Operating machinery	.....	865,629.73	.....
61 Emergency dams	.....	29,927.21	.....
Total	.....	$ 9,405,219.16	.....
Miraflores east dam—			
62 Excavation	15,765	$ 51,253.86	.....
Miraflores west dam—			
63 Dry filling	1,488,419	$ 730,255.56	$0.4886
64 Hydraulic filling	.....	39,473.76	.....
65 Masonry, core wall	590	2,668.43	4.5228
66 Dry excavation	1,863	23,252.74	12.4813
Total	.....	$ 795,650.49	.....
Miraflores spillway—			
67 Ironwork	.....	$ 51,094.07	.....
Miraflores locks—			
68 Dry excavation, diversions	5,885	$ 2,028.98	$0.3448
69 Dry excavation, in locks	2,222,582	2,063,288.45	0.9283
70 Dredging excavation	309,647	142,379.66	0.4598
71 Hydraulic excavation	332,703	195,299.02	0.5870
72 Preparing foundations, excavation	402,504	759,805.56	1.8877
73 Preparing foundations, wooden piles, lin. ft.	31,325	58,927.08	1.8812
74 Masonry	1,356,129	7,116,417.00	5.2476
75 Gates	.....	628,457.99	.....
76 Ironwork	.....	859,126.84	.....
77 Back-filling	1,507,930	543,196.33	0.3602
78 Filling centre wall	20,012	26,353.53	1.3169
79 Operating machinery	.....	637,235.41	.....
80 Emergency dams	.....	15,995.18	.....
Total	.....	$13,048,511.03	.....
La Boca locks and dams (abandoned)—			
81 Dry excavation	78,233	$ 158,343.29	$2.0240
82 Construction dam	.....	315,350.07	.....

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Items.	Total to December 31, 1912. Quantities.	Amount.	Unit cost.
83 Construction locks	.....	$ 159,306.40	.....
Total	.....	$ 632,999.76	.....
84 Naos Island breakwater	1,121,233	$ 300,118.89	$0.2677
85 Terminal facilities, Balboa	.....	736,009.69	.....
Total construction cost, Pacific division	.....	$37,080,158.46	.....
86 Plant and equipment to be absorbed in construction costs after Dec. 31, 1912	.....	$ 1,734,828.08	.....
Total expenditures, Pacific division	.....	$38,814,986.54	.....
87 Lighting and buoying canal	.....	$ 199,474.93	.....
88 Permanent buildings	.....	6,466.99	.....
89 Electric transmission line	.....	619.26	.....
Total expenditures, constr. and engineering	.....	$167,538,493.65	.....

Item No. 43—Central Division dredging excavation prism, preliminiary surveys.

Item No. 45—Represents operation of cement-gun used in facing walls of the cut.

Item No. 64—Pacific Division, Miraflores dam, hydraulic filling. Expenditures represent cost of pipe-lines, flumes, etc. 661,048 cu. yd. have been deposited in the dams from dredges and hydraulic excavation in lock chambers and in prism below the locks. The expense thereof has been charged to excavation.

Items No. 81, 82, 83—Pacific Division, La Boca locks and dams. This expense was incurred prior to the adoption of Miraflores as the site for the lower locks and dam at the Pacific entrance of the canal.

Item No. 84—Naos Island breakwater. Though shown under Pacific Division, the breakwater is being constructed entirely by the Central Division with material from the cut. Only the excess cost of dumping here as compared with regular dumps is charged to this item.

Items No. 40, 46, and 86—The expenditures from plant and equipment are absorbed in the construction costs on the basis of estimated cost of the plant and estimated quantities of work to be done. The amounts shown under these items represent the balances which were to be absorbed into construction costs after December 31, 1912.

General—When the excavated material is used for filling, such as dams, back-filling, etc., the cost of dumping only is charged to the item benefited, other expenses being charged to excavation.

DAM CONSTRUCTION

Detailed cost per cubic yard for quarter ended December 31, 1912.

Items.	Gatun dam. Total.	Pedro Miguel dam. Total.	Miraflores dam. Total.
Excavation—Quantities, cu. yd.	.....	930	13,295
Drilling	.....	.....	$0.0678
Blasting	.....	.....	0.0025
Excavation by hand	.....	$3.4473	0.6462
Transportation	.....	.....	0.0254
Tracks	.....	.....	0.3835
Trestles	.....	.....	0.1332
Pumping	.....	.....	0.0410
Maintenance of equipment	.....	0.4881	0.1460
Plant arbitrary	.....	.....	0.1852

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Items.	Gatun dam. Total.	Pedro Miguel dam. Total.	Miraflores dam. Total.
Excavation by pumps	.....	.....	$0.1474
Division expense	.....	$0.2590	0.0713
Total division cost	.....	$4.1944	$1.8495
Administrative and general expense	.....	0.3663	0.1372
Total cost	.....	$4.5607	$1.9867
Masonry—Quantities, cu. yd	.....	40	440
Concrete	.....	$26.6075	$2.4887
Plant arbitrary	.....	0.7000	0.5400
Maintenance of equipment	.....	0.1170	0.1096
Division expense	.....	1.8258	0.0822
Total division cost	.....	$29.2503	$3.2205
Administrative and general expense	.....	2.6790	0.1511
Total cost	.....	$31.9293	$3.3716
Dry Fill—Quantities, cu. yd	585,729	45,993	145,865
Clearing site	.....	.....	.....
Excavation	$0.0945	.....	.....
Tracks	0.0845	$0.0999	$0.1024
Trestles	0.0002	.....	.....
Transportation	0.0817	0.0565	0.0689
Filling	0.0959	0.0715	0.0638
Maintenance of equipment	0.0487	0.0423	0.0485
Plant arbitrary	.....	.....	0.0800
Division expense	0.0309	0.0149	0.0152
Total division cost	$0.4364	$0.2851	$0.3788
Administrative and general expense	0.0380	0.0202	0.0228
Total cost	$0.4744	$0.3053	$0.4016

LOCK AND SPILLWAY CONSTRUCTION

Detailed cost per cubic yard for quarter ended December 31, 1912.

Items.	Gatun spillway. Total.	Gatun locks. Total	Pedro Miguel locks. Total.	Miraflores locks. Total.
Dredging Excavation—Quantities cu. yd	.....	105,978	.....	.....
Operation dredges	.....	$0.2068	.....	.....
Repairs dredges	.....	0.0732	.....	.....
Pipe-lines	.....	0.0078	.....	.....
Coffer-dams	.....	.....	.....	.....
Dikes	.....	.....	.....	.....
Drilling	.....	.....	.....	.....
Blasting	.....	.....	.....	.....
Plant arbitrary	.....	0.1470	.....	.....
Division expense	.....	0.0193	.....	.....
Total division cost	.....	$0.4541	.....	.....

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Items.	Gatun spillway. Total.	Gatun locks. Total.	Pedro Miguel locks. Total.	Miraflores locks. Total.
Administrative and general expense....	.....	$0.0155	.....	.....
Total cost	.....	$0.4696	.....	.....
Preparing Foundations—Excavation—				
Quantities, cu yd.....	.....	21,568	5,506	20,060
Drilling	.....	$0.0104	$0.2325	$0.0064
Blasting	.....	0.0302	0.0724	0.0180
Loading by power	.....	0.2885	0.0740	.....
Loading by hand	.....	0.2050	1.0419	1.2382
Transportation	.....	0.1102	0.1843	0.0371
Tracks	.....	0.0673	0.2449	0.1868
Dumps	.....	.....	.....	.....
Pumps	.....	.....	0.0904	0.0778
Coffer-dams	.....	.....	.....	.....
Maintenance of equipment	.....	0.1294	0.3302	0.1697
Plant arbitrary	.....	.....	.....	0.2101
Division expense	.....	0.0562	0.1255	0.1138
Total division cost	.....	$0.8972	$2.3961	$2.0579
Administrative and general expense....	.....	0.0956	0.1532	0.1739
Total cost	.....	$0.9928	$2.5493	$2.2318
Preparing Foundations—Wooden Piling—				
Quantities, lin. ft.....	.....	41,220	.....	13,440
Wooden piles in place.....	.....	$0.6672	.....	$0.1783
Maintenance of equipment	.....	0.0017	.....	.....
Division expense	.....	0.0149	.....	0.0089
Total division cost	.....	$0.6838	.....	$0.1872
Administrative and general expense....	.....	0.1000	.....	0.0101
Total cost	.....	$0.7838	.....	$0.1973
MASONRY.				
Concrete—Quantities, cu. yd.....	5,175	11,842	19,411	126,550
Cement	$1.4844	$1.3582	$2.0153	$1.8292
Stone	1.0835	1.6052	0.7339	0.7318
Sand	0.5697	0.6010	0.4385	0.4373
Mixing	0.6202	0.6876	0.8935	0.2827
Total cost	$4.5278	$4.2520	$4.0812	$3.2810
Large Rock—Quantities, cu. yd.....	.....	.....	.....	.....
Cost	.....	.....	.....	.....
Masonry—Quantities, cu. yd.....	5,175	11,842	19,411	126,550
Concrete	$4.5278	$4.2520	$4.0812	$3.2810
Large rock	.....	.....	.....	.....
Wood forms	1.6292	2.1388	0.7249	0.5030
Steel forms	.....	.....	.....	0.0080
Placing	1.0497	1.2545	0.4453	0.4286

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Items.	Gatun spillway. Total.	Gatun locks. Total.	Pedro Miguel locks. Total.	Miraflores locks. Total.
Reinforcements	.....	.....	.....	.....
Pumps	.....	$0.2496	$0.0816	$0.0311
Power	.....	0.1562	.....	0.0398
Coffer-dams	*0.0502	.....	.....	.....
Maintenance of equipment	0.2324	0.4159	0.0949	0.1678
Plant arbitrary	0.5340	0.9380	0.7000	0.5406
Division expense	0.2204	0.3718	0.1518	0.1081
Total division cost	$8.1433	$9.7768	$6.2797	$5.1080
Administrative and general expense	0.7502	1.2433	0.2846	0.3349
Total cost	$8.8935	$11.0201	$6.5643	$5.4429
Masonry, Reinforced—Quantities, cu. yd.	363	2,531	638	15,895
Cement	$1.4450	$1.7989	$2.0958	$2.0410
Stone	1.8055	1.1071	0.6799	0.7020
Sand	0.5927	0.6083	0.4825	0.4414
Mixing	0.7321	0.9594	2.0247	0.7129
Wood forms	5.0597	4.4352	2.2671	2.9283
Steel forms	.....	.....	.....	*0.0010
Power	.....	0.1716	.....	0.0175
Placing	0.5597	2.7789	8.5884	1.0535
Reinforcements	4.4948	0.5516	5.5486	1.4000
Pumps	.....	.....	0.0928	0.0314
Maintenance of equipment	0.2399	0.9115	0.4482	0.1206
Plant arbitrary	0.5340	0.9380	0.6704	0.5391
Division expense	0.4763	0.7560	1.0279	0.4151
Total division cost	$15.9397	$15.0165	$23.9263	$10.4018
Administrative and general expense	2.4340	2.1197	2.4208	1.0008
Total cost	$18.3737	$17.1362	$26.3471	$11.4026
Total Masonry—Quantities, cu. yd.	5,538	14,373	20,049	142,445
Total cost	$9.5149	$12.0971	$7.1938	$6.1079
Back-filling—Quantities, cu. yd.	.....	94,621	28,714	232,767
Drilling	.....	$0.0109	.....	.....
Blasting	.....	0.0262	.....	.....
Loading	.....	0.0306	.....	.....
Tracks	.....	*0.2279	$0.1805	$0.1030
Transportation	.....	0.1208	0.1578	0.0674
Filling	.....	0.0911	0.1700	0.0736
Maintenance of equipment	.....	0.0490	0.0969	0.0377
Plant arbitrary	.....	.....	0.0800	0.0900
Division expense	.....	0.0278	0.0324	0.0164
Total division cost	.....	$0.1285	$0.7176	$0.3881
Administrative and general expense	.....	0.0385	0.0650	0.0286
Total cost	.....	$0.1670	$0.7826	$0.4167

*Indicates credit.

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Items.	Gatun spillway. Total.	Gatun locks. Total.	Pedro Miguel locks. Total.	Miraflores locks. Total.
Filling Centre Wall—Quantities, cu. yd...	.....	.....	34,914	3,893
Loading	.....	.....	.....	.....
Tracks	.....	.....	$0.1380	.....
Transportation	.....	.....	0.0876	$0.0020
Filling	.....	.....	0.0984	0.9883
Power	.....	.....	.....	0.0018
Maintenance of equipment	.....	.....	0.0718	0.0886
Plant arbitrary	.....	.....	0.0800	0.0901
Division expense	.....	.....	0.0174	0.0769
Total division cost	.....	.....	$0.4932	$1.2477
Administrative and general expense....	.....	.....	0.0464	0.1205
Total cost	.....	.....	$0.5396	$1.3682

DRY EXCAVATION—PRISM

Detailed cost per cubic yard for quarter ended December 31, 1912.

Items.	Central Div. Total.	Pacific Div. Total.
Dry Excavation—		
Quantities, cu. yd....	3,161,001	759,985
Clearing	.....	.....
Drilling	$0.0648	$0.0862
Blasting	0.0526	0.0159
Loading	0.0548	0.0941
Tracks	0.0957	0.2008
Transportation	$0.0902	$0.0969
Dumps	0.0608	0.0173
Pumps	0.0088	0.0309
Maintenance of equipment	0.1152	0.0873
Plant arbitrary	.....	0.0701
Division expense	0.0132	0.0276
Total division cost.....	$0.5561	$0.7271
Administrative and general expense	$0.0315	$0.0557
Total cost	$0.5876	$0.7828

DREDGING EXCAVATION—PRISM

Detailed cost per cubic yard for quarter ended December 31, 1912.

Items.	Atlantic Division. Total. Quantities. Cu. yd.	Atlantic Division. Total. Unit cost.	Pacific Division. Total. Quantities. Cu. yd.	Pacific Division. Total. Unit cost.
Clearing	.....	.....	349,747	$0.0013
Operation sea-going suction dredge.....	884,073	$0.0333	521,658	0.0523
Repairs sea-going suction dredge.....	884,073	0.0065	521,658	0.0019
Operation small ladder dredges.....	138,623	0.1620	204,147	0.1123
Repairs small ladder dredges.....	138,623	0.0897	204,147	0.1029
Operation 5-yd. ladder dredge.....	.....	.....	356,755	0.0723
Repairs 5-yd. ladder dredge.....	.....	.....	356,755	0.0448
Operation dipper dredges.....	96,619	0.0822	62,923	0.1544
Repairs dipper dredges.....	96,916	*0.0029	62,923	0.0982
Operation pipe-line dredges.....	938,088	0.0551	.....	.....
Repairs pipe-line dredges.....	938,088	0.0332	.....	.....
Pipe-lines	938,088	0.0197	.....	.....
Dikes	260,612	0.0028	73,901	*0.0511
Operation tugs, clapets, and scows.....	235,242	0.0938	623,825	0.0814
Repairs tugs, clapets, and scows.....	235,242	0.0577	623,825	0.0437
Drilling	182,083	0.0363	274,512	0.1173
Blasting	182,083	0.1121	274,512	0.1507

*Indicates credit.

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Items.	Atlantic Division. Total. Quantities. Cu. yd.	Unit cost.	Pacific Division. Total. Quantities. Cu. yd.	Unit cost.
Operation drill barges	.....	.....	274,512	$0.0907
Repairs drill barges	.....	.....	274,512	0.0071
Operation rock-breakers	.....	.....	274,512	0.0138
Repairs rock-breakers	.....	.....	274,512	0.0144
Small boats	2,057,403	$0.0014	1,145,483	0.0053
Repairs miscellaneous equipment	2,057,403	0.0012	1,145,483	0.0175
Plant arbitrary	2,057,403	0.0470	1,145,483	0.0068
Division expense	2,057,403	0.0062	1,145,483	0.0098
Total division cost	2,057,403	$0.1736	1,145,483	$0.3123
Administrative and general expense	2,057,403	0.0117	1,145,483	0.0297
Total cost	2,057,403	$0.1853	1,145,483	$0.3420
Earth excavation, %	1,875,320	91.15	870,971	76.04
Rock excavation, %	182,083	8.85	274,512	23.96

SAND PRODUCTION

Detailed cost per cubic yard for quarter ended December 31, 1912.

Items.	Chamé. Total.
Dredging—Quantities, cu. yd.	116,677
Operation dredges	$0.0889
Maintenance of equipment	0.0214
Total	$0.1103
Plant arbitrary	$0.0100
Total cost of production	$0.1203
Towing—Quantities, cu. yd.	116,677
Operation tugs and barges	$0.0917
Maintenance of equipment	0.0398
Plant arbitrary	0.0200
Total	$0.1515
Unloading—Quantities, cu. yd.	114,677
Operation cableways and cranes	$0.0953
Power	0.0183
Maintenance of equipment	0.0624
Plant arbitrary	0.0513
Total	$0.2273
Rail transportation to storage—	
Quantities, cu. yd.	114,677
Operation of trains	$0.0513
Repairs to tracks	0.0276
Dumping in storage	0.0169
Maintenance of equipment	0.0274
Plant arbitrary	0.0400
Total	$0.1632
Division expense	$0.0207
Total cost in storage	$0.6830

STONE PRODUCTION

Detailed cost per cubic yard for quarter ended December 31, 1912.

Items.	Ancon quarry. Total.
Quarrying—Quantities, cu. yd.	172,272
Stripping	$0.0003
Drilling	0.0626
Blasting	0.0467
Loading	0.0406
Transportation	0.0539
Tracks	0.0302
Maintenance of equipment	0.0567
Plant arbitrary	0.1600
Total	$0.4510
Crushing—	
Operation crushers	$0.0190
Stone-bins and conveyors	0.0041
Power	0.0192
Maintenance of equipment	0.0370
Plant arbitrary	0.0427
Total	$0.1220
Rail transportation to storage—	
Operation of trains	$0.0497
Dumping in storage	0.0239

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Maintenance of equipment	$0.0257
Plant arbitrary	0.0600
Total	$0.1593
Division expense	$0.0201
Total cost in storage	$0.7524

HYDRAULIC EXCAVATION—PRISM

Detailed cost per cubic yard for quarter ended December 31, 1912.

Items.	Pacific Div. Total.
Quantities, cu. yd	174,263
Blasting	*$0.0001
Pumping station	0.0552
Pipe-lines and monitors	0.0331
Dredging pumps	0.0252
Dikes	0.0110
Maintenance of equipment	0.0411
Power	0.1009
Plant arbitrary	0.7145
Division expense	0.0100
Total division cost	$0.9909
Administrative and general expense	0.0126
Total cost	$1.0035

COLON BREAKWATER

Detailed cost per cubic yard for quarter ended December 31, 1912.

Porto Bello Large Rock.	Total.
Quarrying—Quantities, cu. yd	42,736
Stripping	$0.4563
Drilling	0.1105
Blasting	0.2484
Loading	0.1117
Transportation	0.1107
Tracks	0.3877
Loading on barges	0.1651
Power	0.1138
Maintenance of equipment	0.5564
Plant arbitrary	0.3010
Total	$2.5616
Towing—	
Operation tugs and barges	$0.2961
Maintenance of equipment	0.3033
Plant arbitrary	0.4040
Total	$1.0034
Placing—	
Operation of floating derricks	$0.1326
Maintenance of floating derricks	$0.1065
Operation cranes	0.1512
Operation trains	0.0815
Dumping	0.0119
Maintenance of equipment	0.1985
Plant arbitrary	0.1640
Total	$0.8462
Trestles	$0.1999
Tug service, miscellaneous	0.1046
Maintenance of equipment	0.0724
Division expense	0.2747
Total division cost	$5.0628
Administrative and general expense	0.3724
Total cost	$5.4352

*Denotes credit.

PERMANENT POWER-HOUSE, GATUN

Detailed cost per cubic yard for quarter ended December 31, 1912.

Preparing Foundations—	Total.
Quantities, cu. yd	4,012
Drilling	$0.0019
Blasting	0.0180
Loading by power	0.1719
Loading by hand	1.4222
Tracks	0.1583
Transportation	0.1202
Maintenance of equipment	0.1245
Plant arbitrary	0.0578
Division expense	0.2091
Total division cost	$2.2839
Administrative and general expense	0.2240
Total cost	$2.5079
Masonry Sub-structure—	
Quantities, cu. yd	453
Cement	$1.5813
Stone	1.9621
Sand	0.5850
Forms	4.1760
Mixing	1.3786
Reinforcement	0.0658
Placing	3.0798
Coffer-dams	0.4392
Maintenance of equipment	0.2832
Plant arbitrary	0.5340
Division expense	0.6314
Total division cost	$14.7164
Administrative and general expense	1.0436
Total cost	$15.7600

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Company Reports

The Nevada-California Power Co. reports the following results for the year ended December 31, 1912, as compared with the previous year:

	1912.	1911.
Gross earnings	$872,844	$772,846
Net after taxes	580,572	560,025
Bond and other interest	157,438	167,323
Reserve and discount	14,350	20,650
Bonds redeemed	81,757	74,302
Dividends	(4)182,660	(2)91,330
Balance for surplus	144,367	206,420

This company generates power on Bishop creek, Inyo county, California, and supplies mining districts in Nevada, besides other industries in southern California.

The Union Oil Co. reports the following work done in 1912:

Area of land controlled, acres	240,808
'Rigs' in operation	28
Holes drilled, feet	62,507
Producing wells	330
Storage tanks	502
Pipe-lines, miles	650
Oil pumped, barrels	20,500,000
Gross profit	$4,261,000
Net profit	2,839,738
Dividends	2,232,891
Surplus	10,038,468
Value of oil stocks	3,936,136
Expenditure on equipment for 1913, recommended	3,000,000

The Pacific Gas & Electric Co. has issued a statement covering the March quarter as follows:

Quarter ended March 31—	1913.	1912.	Increase.
Gross	$4,159,590	$3,832,813	$326,777
Op. exp.	2,316,026	2,041,003	275,023
Net	$1,843,564	$1,791,810	$51,753

The General Petroleum Co., in its first annual report, shows a profit of $39,399. Revenue from oil sales was almost exclusively from the field only. The 8-in. pipeline from North Midway to Los Angeles, 158 miles, is in working order, and the product should receive a larger sale. Two refineries are being built, one at Vernon and the other at Mohave, each with 20,000 bbl. daily capacity. Four steamers of 65,000 bbl. capacity each have been chartered. The daily production in 1912 was increased from 3500 to 9500 bbl., and purchased petroleum totaled 10,000 bbl. per day. The total holdings are 23,000 acres in California and 24,500 in Mexico.

The Western Pacific Railroad Co. shows the following for the nine months ended March 31, 1913:

	1913.	1912.
Operating revenue	$4,619,849	$3,896,578
Operating expense	3,374,987	3,202,121
Net op. revenue	$1,244,861	$694,457
Outside operations	*8,557	*30,904
Total net revenue	$1,236,304	$663,552
Taxes	199,647	135,419
Operating income	$1,036,657	$328,132

*Deficit.

Estimated earnings for April 1913, $518,300.
Actual earnings for April 1912, $443,842.97.

The Great Western Power Co. reports as follows for the first four months of the current year. It shows a steady progressive improvement in earnings and a substantial increase in the surplus. Comparative statement follows:

	1913.
Gross operating income	$862,104
Operating expenses and taxes	288,131
Net operating income	$573,973
Other income	55,284
Net income from all sources	$629,258
Bond interest	378,134
Surplus for 4 months ended April 30, 1913	$251,123
	1912.
Surplus for 4 months ended April 30, 1912	$175,677
Increase 1913 over 1912	$75,445

The Mexican Petroleum Co., Ltd., reports the following results for 1912:

Oil on hand increased, bbl.	983,667
Net profits	$3,076,314
Net surplus	4,115,624

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Book Reviews

TESTS OF REINFORCED CONCRETE BUILDINGS UNDER LOAD. By Arthur N. Talbot and Willis A. Slater. Bull. 64, Engineering Experiment Station, University of Illinois. Pp. 104.

Besides giving the results of tests, this bulletin presents a detailed discussion of the methods and apparatus developed at the University of Illinois for measuring the stresses caused by floor loads in reinforced-concrete buildings. It is shown that these stresses may be determined with a considerable degree of accuracy if care is used in making the test. The bulletin furnishes valuable information on the action of several building floors under load, and will be useful to designers of reinforced-concrete structures. Copies may be obtained upon application to W. F. M. Goss, University of Illinois, Urbana, Illinois.

THE OFFICIAL GOOD ROADS YEAR BOOK OF THE UNITED STATES, 1913. Pp. 548. Ill. Published by the American Highway Association, Washington, 1913.

This, the second year-book published by the Association, is replete with valuable information. While written more for the general public than for the engineer, it contains much that is of value to the latter, and it is an extremely useful book of reference for all interested in road work. The chapters on bonds and on road systems of foreign countries especially contain much condensed information difficult of access elsewhere. Other chapters of especial interest are devoted to convict labor, dust preventives, bridges and culverts, legislation, patents, maintenance and repairs, and state aid.

TOPOGRAPHIC INSTRUCTIONS OF THE UNITED STATES GEOLOGICAL SURVEY. Pp. 241; 4½ by 6½. Ill., index. Washington, 1913.

Since the Topographic Corps of the United States Geological Survey is probably the largest in the world, and the maps made by the organization have an enviable reputation for accuracy, considering scale, the manual of instructions issued to the field officers is of much interest. The present handbook has been prepared under the direction of R. B. Marshall, chief geographer, and is a complete compendium of information available previously only in numerous circulars. While intended only for members of the corps, copies presumably will be made generally available if there be sufficient demand among engineers to warrant printing a public edition. The work of the topographers of the Survey is almost unique, and they have brought to unusual perfection the art of sketching contours. With an accurately controlled base, such as is now being made, these contour maps are at once not only most expressive, but are the most widely useful form of engineering maps that can be made for the money. Engineers in many lines of work would benefit greatly from acquiring skill in making just such maps, and will therefore find this modest Government document well worth having.

REPORT ON THE IMPROVEMENT AND DEVELOPMENT OF THE TRANSPORTATION FACILITIES OF SAN FRANCISCO. By Bion J. Arnold. Pp. 475. Ill., index, appendix of tables, and map. San Francisco, 1913.

The gratifying modern tendency to call into consultation the engineer when planning for the future growth of a city is nowhere better exemplified than in this report by Mr. Arnold. For years San Francisco has blundered along with no specialist as adviser regarding transportation problems. Officials of the United Railroads have worked along the usual lines, making the best of a bad situation and operating under conditions where the maximum gain to the promoter was the final controlling factor in decisions. As a result, the roads belonging to the company are capitalized at more than their replacement value, money for extensions cannot be taken from earnings, and the city will no longer grant franchises upon the terms that investors in and promoters of street railway lines have learned to expect. In the meantime the city continues to grow, and there is an immediate necessity for providing transportation for 40,000 people per day to the Exposition, to say nothing of a peak-load on certain days that probably cannot be handled. It was evidently high time to call in some one who knew how to get at the facts and what to advise, and the money spent on the report, whether Mr. Arnold's recommendations be followed completely or not, was money well spent. The report is too voluminous to review in detail.

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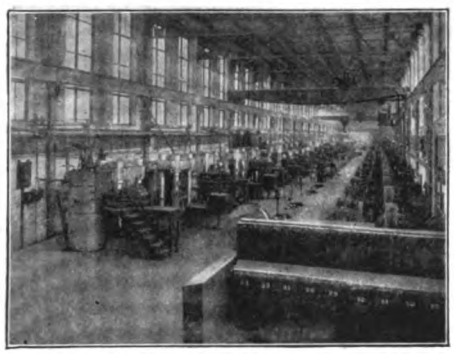
Industrial Progress

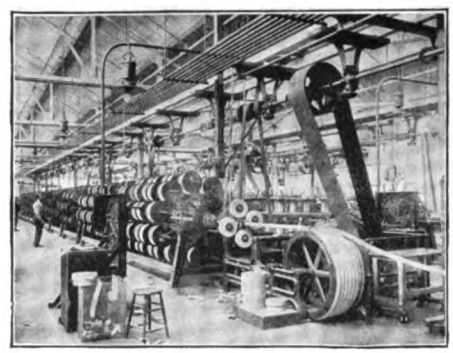
How Telephone Cable is Made

Merely stating that modern telephone cable consists of a group of copper wires, insulated by a wrapping of manila paper, twisted into pairs, and enclosed in a lead sheath, does not convey any idea of the complexity of the processes by which it is manufactured. These processes, as carried on in the Hawthorne factory of the Western Electric Co., are described in a recent issue of the *Western Electric News*.

The materials of which cable is composed are copper wire, manila paper, tin, and lead. These are furnished by the carload, the wire rolled in coils, the paper wound on spools, and the tin and lead in bars, known as pigs. The wire is known as soft drawn. It has been thoroughly annealed; that is, softened and made flexible, and drawn to the proper diameter, and differs from the so-called hard-drawn wire used in outside line construction in its toughness and flexibility. The paper, which varies in thickness from 0.0025 to 0.014 in., is especially made from the best manila rope-fibre and is consequently very tough and durable. The metals are chemically pure tin and lead.



BATTERY OF LEAD PRESSES.



THE STRANDING MACHINE.

The first process that is actually carried on in the cable, rubber, and insulating shops at Hawthorne, is that of insulating the copper wire with its paper wrappings. The insulting machine consists of a number of revolving discs, an equal number of capstans, or large pulleys, and the take-up reels. The bare wire is coiled loosely around large iron spindles. From there it passes over the pulleys at the top of the machine through the centre of the revolving discs. On the face of each disc a pad of the insulating paper is placed, and as the wire is pulled through the hole in the centre by the capstan beneath, the disc revolves, winding the paper around the wire in the form of an endless spiral. The insulated wire then passes over the capstan and is wound upon the take-up reel below. Each disc is driven by an individual motor and applies the paper to the wire at the rate of 2400 to 3000 wraps or turns per minute. Various colored papers are used, in order to make it easy to identify different sizes of wire or different pairs of wires in the finished cable.

The insulated lengths of wire are now ready to be twisted into pairs. Two of the take-up reels containing insulated wire of the same color are placed in spindles in the machine. A capstan at the top of the machine then draws the wires through a yoke —a revolving plate pierced by two holes, through which the wires pass—twisting them together, and leads the twisted pair to another take-up reel. The machine is so adjusted that the length of the twist, that is, the number of twists to the foot, may be altered at will. Different lengths of twist are used for different gauges or sizes of wire.

The twisted pairs of wires now go to the stranding machine to be formed into a cable. This machine consists of a number of revolving drums, which look like enormous skeleton spools. On the outer circumference of these drums are arranged the reels containing the various pairs. A large capstan draws the centre pair or pairs of wires

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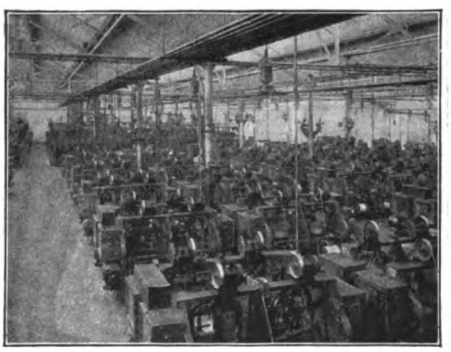
straight through the centre of the machine; at the same time the drums revolve and the other pairs are unwound from the reels and are twisted in alternate directions around the centre. The finished core, as the unsheathed cable is called, emerges from the machine and is wound upon the capstan. The last layer of pairs is covered with a double wrapping of paper, to protect the core from the lead sheathing. In order to cut the cable to the lengths desired by the customer, one of the centre pairs is carefully measured and the position of the end of this pair marked on the outside of the core. As it is often important to the customer that the lengths be absolutely correct, a check measurement is usually obtained, either by means of a recording device on the front of the standing machine or by weighing the completed cable.



INSULATING MACHINES.

ON REELS READY FOR SHIPMENT.

After leaving the stranding machine, the entire length of cable core is carefully tested to make sure that none of the wires are broken, and also that the paper insulation is perfect. The next process, that of drying, is very important, for the quality and efficiency of the cable depend to a large extent upon the care with which it is carried out. The core is placed in gas ovens heated to 215 or 230°F., and is kept there for a period ranging from 15 to 48 hours, depending on the size and length of the core, the amount of insulation, and the character of service for which the finished cable is intended.

When the core has been thoroughly dried, it is put through the last manufacturing process, that of applying the lead sheath. The lead press, or sheathing machine, on which this operation is performed, is practically a machine for making lead pipe. It consists of a huge pot, or container for holding the metal, a core and die-box, and a hydraulic press. The container is filled with molten lead, to which an alloy of 3% tin has been added. The bottom of the container opens into the top of the core and die-box. The core is a pipe through which the cable passes; the die is a mold surrounding the core. The cable to be covered passes into the back of the machine, through the core and the die. By this time the lead in the container is no longer liquid, but has cooled sufficiently to be in a plastic state. It would not do to apply the molten lead to the cable core, because the hot metal would burn the paper insulation off the wires. The hydraulic press, working at an enormous pressure, forces the plastic lead through the die, or mold, and around the cable core, thus surrounding the paper-covered wires with a continuous lead sheath of any length.

As soon as the finished cable is cool enough to handle, it is given a final and thorough electrical test. As it is essential that every cable contain at least as many perfect pairs of wires as are called for in the order, a few extra pairs are usually included in order to make up for any defective pairs that may be detected in the course of the final inspection.

When the cable has tested satisfactorily, the ends of the core are impregnated in paraffin and the sheath is sealed so as to prevent possible entrance of moisture, after which the finished product is ready for shipment. Testing of the cable is one of the most important phases of its manufacture.

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The processes just described are those for making telephone cable in general. There are, however, different types of cable, and their manufacturing processes vary. The so-called 'silk and cotton cable', which is used largely on the telephone subscriber's premises, particularly for inter-phones, differs from the standard in that the wrapping of the bare wire consists of silk and cotton in place of paper. The so-called 'wool cable', which is used in telephone exchanges between the manholes underground and telephone exchanges, has a wrapping of wool in place of the paper, the wool offering a greater resistance to moisture. Submarine cables carry both heavier insulation and heavier sheath.

The modern lead sheathing process places no limit on the length of a single cable. A cable recently made for the Western Union Telegraph Co. consisted of two lengths of 37-pair cable, each of which was 5500 ft.—over a mile—long. The thickest cable made contains 600 pairs of No. 22 gauge wire, with an outside diameter of 2⅝ inches.

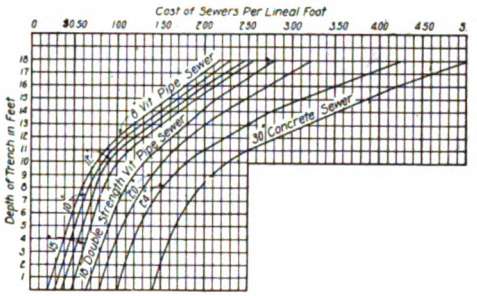
The cable factory is a one-story building, in which enormous weights of raw material are handled, 2000 tons of paper, 10,000 tons of copper, and 30,000 tons of lead being made into cable in a single year. There is not a single lost motion as the manufacture progresses. At the east end of the building, cars containing raw material are unloaded and the sequence of the departments—insulating, twisting, stranding, baking and sheathing—is arranged so as to correspond with the order in which the cable evolves. At the other end of the plant the finished product is rolled into waiting cars. This cable factory is an excellent example of the successful application of the principles of scientific management.

Engineers' Note Book

A Diagram for Estimating the Cost of Laying Sanitary Sewers*

By E. O. EICHELBERGER†

The accompanying diagram will be found useful in making preliminiary estimates of the cost of sanitary sewers, exclusive of manholes, flush tanks, and other appurtenances. The diagram was compiled from the average of 50 proposals made by contractors to the city of Dayton, Ohio, during the year 1912. It gives at a glance the cost of furnishing and laying the various sizes of sewers from 8 to 30 in. diam., per lineal foot, including the cost of excavating and back-filling trenches up to 18 ft. in depth.



COST OF LAYING SEWERS.

The diagram can be adjusted to the fluctuations of prices of vitrified pipe by comparing the cost of furnishing and laying the various sizes of pipe, as found on the bottom line of the diagram, with present quotations of pipe in carload lots plus the local cost of handling and laying same, and by adding to or subtracting the difference so found from the result as given in the diagram. For example, by consulting the diagram we find the cost of laying 8-in. pipe including trench at a depth of 8 ft. to be 58c. per lineal foot. The cost of furnishing and laying the pipe (bottom line) is 20c. per lineal foot. If it is found that the present quotation of 8-in. pipe plus the cost of handling and laying same is 22c. per lineal foot, a correction in the above result (58c.) should be made by the addition of 2c., bringing the total cost to 60c. per lineal foot. Should the price of both pipe and trench need adjustment, the same should be done on a percentage basis.

Owing to the recent increases in the price of sewer pipe and state legislation fixing eight hours as a day on public work, the Dayton engineering department is increasing its estimates 20% over the results as shown by the diagram.

*Abstract from *Engineering & Contracting*, February 12, 1913.
†Assistant City Civil Engineer, Dayton, Ohio.

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Hints on Practice

Foam as a Gasoline Fire Extinguisher

Water, it is well known, serves only to increase a fire in petroleum products, although it is effective against alcohol fires. Exclusion of air is the only means of effectively extinguishing an incipient blaze in gasoline, benzine, or oil. In the method invented by Laurent in Germany, which has recently been officially tested, the agent employed is foam. A solution of sodium carbonate mixed with foam-producing substances, and a solution of alum, combined in equal parts, produce, without precipitation of any solid, a thick, yellowish white foam which can be pumped and sprayed as effectively as water. A mixture of one litre (0.264 gal.) of each of the solutions produces 15 litres (3.96 gal.) of foam weighing 140 grams per litre (18.6 oz. per gallon). Sprayed on a burning liquid, the foam, as it accumulates, spreads gradually over the whole burning surface, effectively shutting out the air and thus extinguishing the fire. As to its efficiency in extinguishing fires, two typical results of the tests may be quoted. A fierce blaze in a tank of benzine 40.35 sq. ft. in area and 20 in. deep, was extinguished in 78 seconds. In another case, with a larger expenditure of chemicals, only 13 seconds were required to quench a fire in another tank that was 6.56 ft. in diameter and 8.5 ft. deep.—*Compressed Air Magazine.*

How Explosives Work

All commercial explosives owe their power of doing work to the expansive force of the great volume of gas into which they are converted at the occurrence of the explosion. The pressure exerted by this gas in the drill-hole or other confined space in which the explosion is brought about is what makes explosive substances of value in mining or other industries, and is the primary cause of all those manifestations of energy that follow the firing of a charge. Common black blasting powder, on explosion, produces about 390 times its own volume of permanent gases; 40% dynamite produces about 530 times its own volume of permanent gases, and nitroglycerine produces somewhat more than 747 times its own volume of permanent gases. These proportions of volume of gases to volume of explosive are those that would be found if the gases were measured under normal conditions of temperature and pressure, but at the moment of explosion the gases are highly heated and therefore tend to occupy a volume much greater than the figures given above.

Air-Lift Pumping

THE following is the record of a series of tests of an air-lift water pumping system conducted at St. Paul, Minnesota, in July 1911:

Well No.:	1.	2.	3.
Diameter, in.	10	10	10
Depth, ft.	700	1000	700
Static head, ft.	19	20	12
Drop, ft.	28.6	33.35	41.35
Elevation, ft.	30	29	30
Total lift, ft.	77.6	82.35	83.35
Submergence, ft.	146.4	140.65	140.65
100% ft.	224	223	224
Well No.:	**4.**	**5.**	**6.**
Diameter, in.	10	10	10
Depth, ft.	700	700	700
Static head, ft.	20	19	19
Drop, ft.	33.35	34.35	34.35
Elevation, ft.	29	29	30
Total lift, ft.	82.35	82.35	83.35
Submergence, ft.	140.65	140.65	140.65
100% ft.	223	223	224

Average lift, ft.	81.87
Average submergence	141.61
Percentage of submergence	63
R.p.m. compressor	80.26
Pressure on receiver	72
Indicated horse-power	239.7
Gallons per minute pumped	4401
Theoretical horse-power	90.98
Efficiency, %	38

IF the threads on a bolt or nut are covered with rust, or fit tightly, clean them out with a mixture made as follows: Mix some powdered emery with any kind of grease, and smear the threaded parts, both inside of the nut and on the bolt, then turn the nut on the bolt, and run it back and forth over the threads. This method will be found effective even in the most stubborn cases.

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Power, Gas, and Electricity

San Francisco.—The Pacific Gas & Electric Co. has submitted bids for furnishing gas and electric light to the city during the coming fiscal year. There will be a saving to the city for the year of about $4500. The double-inverted street gas-lamp, for which the city is paying 8.5c. per lamp per night, is listed at 8c., while the electric arc-lights, for which the city now pays 19c., are listed at 18.5 cents.

The California Railroad Commission reports as follows: The Pacific Gas & Electric Co. was authorized to issue $5,000,000 debentures. The same company has applied for a certificate of public convenience and necessity, for the construction of three additional power plants on the extension of Bear river, Placer county, and the construction of a transmission line from the Bear river development station, to Nicolaus in the Sacramento valley. It is stated that the construction will provide for 35,000 hp. at the cost of $2,396,000. The Great Western Power Co. applied for a modification of its recent order authorizing an issue of $4,411,000 in bonds. The company asks that money heretofore authorized for new lines, sub-stations and transformer sets to the amount of $92,562 be made available under a modified order for extensions in the Napa district, the Oakland district, the Petaluma district, the island district, and for minor purposes of general improvements.——The Pacific Gas & Electric Co. and the San Jose Water Co. applied for an order authorizing them to enter into an agreement by which the gas company will convey to the water company the rights to the use of the waters of Los Gatos creek for $25,000.

Los Angeles.—The Board of Supervisors has granted a 40-year franchise to the Los Angeles Gas & Electric Corporation to operate mains in certain sections of the county. For all mains laid, $15 per mile is to be paid, and the county receives 2% of the gross earnings.——Permission to sell natural gas to local distributing companies has been granted to the Southern California Gas Co., which has leased the pipe-line and natural gas contracts of the Midway Gas Co.——Natural gas from Kern county, brought through about 125 miles of 12-in. pipe to Los Angeles, was delivered early in May for the first time for fuel purposes at the power-generating plants of the Southern California Gas and Los Angeles Gas & Electric companies. The gas is producing 1000 to 1200 b.t.u. The price was set tentatively at 18c. per 1000 cu. ft.——The municipal lighting plant at Pasadena is valued at $580,745. Profits during the year ended March 29, 1913, amounted to $63,364.

Loyalton.—The Mountain Development Co. will begin construction of its reservoir and power plant near Sattley on June 15. The power to be developed will be 3500 hp., and the cost $180,000.

Biggs.—The Northern California Power Co. has begun serving to the Oro Electric Co. 2000 hp. This amount will be gradually increased until it reaches 15,000 to 20,000 hp.

Smart.—The Pacific Gas & Electric Co. has started work again on the great Lake Spaulding water scheme. The total height of the dam will be 305 ft., and 1000 cu. yd. of concrete is being laid daily.

Fresno.—The Midland Counties Public Service Co. has applied to the Railroad Commission for leave to take over a number of water, gas, and electric corporations, operating in Fresno county and elsewhere. The companies which desire to be merged are the Coalinga Water & Electric, the Midland Counties Gas & Electric, the Russell-Robinson Water & Electric, and the Paso Robles Electric Light & Power.

Lewiston, Idaho.—The soliciting committee for the Sturm electric line reports that $115,000 had been subscribed, leaving only $5,000 to be raised.

Pocatello, Idaho.—The Beaver River Power Co. was granted a 28-year franchise to supply electricity here, in competition with the Kuhn company. After two years operation the former company pays the city council 1% of the gross revenue, and 1.5% at the end of 20 years.

Salt Lake, Utah.—The Logan canyon power plant, owned by the state, is to supply state institutions with energy, transmitted through the transformers, and lines of the Utah Light & Railway Co. and the Utah Power & Light Company.

Spokane, Washington.—M. C. Osborn, commercial agent of the Washington Water Power Co., states that construction work was started on a 54-mile extension from Davenport. This is a 60,000-volt high-power transmission line, and from it power will be furnished to Wilbur, Creston, Almira, and Hartline, in the Big Bend country.

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Streets and Roads

San Francisco.—The Old Mission Portland Cement Co., whose plant is at San Juan Bautista, San Benito county, has secured a contract with the State Department of Engineering for the supply of 1,500,000 bbl. of cement. For some time past the state has been paying up to $1.50 and the general market $1.90 per barrel. The contract price is $1.15 per barrel, and the delivery is spread over 20 months, with privilege of renewal.

Sacramento.—The State Highway Commission, on May 20, ordered surveys to be made of a new highway, known as route 13, 45 miles long, from Farmington to Sonora. Bids for route 2 in Santa Clara county, one mile, were $7887 and $9984; in Ventura county, 7.5 miles, from $51,869 to $65,523; and in Los Angeles county, route 2, 11.25 miles, from $101,997 to $141,065. The Public Works Department of Sacramento let the following bids for street paving: Benjamin Ford and Fred H. Stout, $26,169; Fairchild-Gilmore-Wilton Co., $16,502; Barber Asphalt Paving Co., $10,366.

adequately and prevent corporations cutting up the roads in laying pipes and then failing to repair the damage. The supervisors will not issue any permits to corporations to lay pipes unless the applications are approved by F. H. Joyner, chief county highway engineer.

Meridian.—The Northern Electric and the Sutter and Colusa counties' bridge was opened on May 1. This crosses the Sacramento river, and cost $241,000.

Peanut.—The state highway from this town westward into Humboldt county is now open for traffic. Two steel bridges remain to be built.

Weaverville.—On May 7, the White bill, appropriating $10,000 for highway construction between North Fork and South Fork on the Humboldt county line on the west, was agreed to in the legislature at Sacramento.

St. Maries, Idaho.—The streets here will be graded at a cost of $80,000.

Ritzville, Washington.—The county commissioners have accepted the bid of Roy E. Nelson for the construction of about two

California State Highway	L.A. County	Dr. T.R.J. Sec. C	Bent & Penney	New Atkinson	F.F. Wonderegat	John D. Marsh	Rogers Bros.	Harry C. Meyer	Leigh Garney	Gillette Montgomery	
Items	Quantities	Estimate	Baker Los Angeles	Los Angeles	Los Angeles	Los Angeles	Co Los Angeles	Venice	Los Angeles	Gray Los Angeles	Note Materials
Total Bid		$103,735.80	$106,768.80	$116,271.00	$125,911.80	$141,066.46		$111,815	$113,577.95	$101,997.76	furnished by
Excav. no classif.	6240 c.y.	.55	.50	.60	.40	.30		.60	.45	.50	State - [illegible]
12" Corrugated	361 l.ft.	1.15	1.60	1.50	1.65	1.60		1.45	1.40	1.00	railing - steel
18" " Iron	399 "	1.60	1.10	2.00	2.15	1.80		2.00	1.75	1.50	Portland cement
24" " Pipe	668 "	2.10	2.60	2.50	2.75	2.15		2.60	2.00	2.00	Asphaltic Oil
30" "	231 "	2.95	3.10	3.00	4.00	3.00		3.35	3.00	2.75	Total value
Class A conc. culverts	256 c.y.	10.00	11.50	10.00	15.00	10.00		10.00	10.00	11.50	$27,914.50
" B cut & mortar	110 c.y.	9.50	12.50	12.00	15.00	10.00		10.00	9.00	9.00	
" B conc. paving	1030 c.y.	4.50	4.75	5.15	6.92	5.45		5.50	7.50	4.00	This work
Asphaltic filling & [illegible]	180 bbl.	1.35	1.50	1.60	1.60	1.50		2.00	2.40	1.35	awarded to
Broken Stone Screenings	850 tons	3.00	3.00	3.50	4.00	4.00		3.35	2.75	3.00	Gillette & Montgomery
Sand	640 c.y.	1.40	2.35	2.00	3.00	2.50		2.50	1.50	1.35	of Gray of
Guard Rail	1260 l.ft.	.40	.45	.40	.55	.60		.50	.39	.40	Los Angeles
Reset Monuments	180 ea.	.65	1.60	2.00	1.00	1.10		1.00	2.00	.50	May 1913

State Highway Section work	Dr. T. Pub. 2 Section A	Bent & Penny.	New Atkinson	John D. Marsh	Harry C. Meyer	Rogers Bros. Co	Leigh Garney	Gillette Montgomery	Gil. Bros. & Street	
Items	Quantities	Estimate	Baker Los Angeles	Los Angeles	Los Angeles	Los Angeles	Los Angeles	Gray Los Angeles	Imp. Co. Fresno	Note Materials
Total Bid		$56,754.56	$56,111.00	$55,615.50	$59,371.00	$60,082.65	$61,165.70	$56,869.90	$56,401.80	$66,281.90	furnished by
Excav. no classif.	1020 c.y.	.50	.65	.75	.82	.60	.60	.685	.70	.70	State - Steel
12" Corr. Iron Pipe	254 l.ft.	1.20	1.60	1.50	1.60	1.65	1.00	1.40	1.25	2.25	Portland cement
18" " " "	68 "	1.65	1.10	2.00	1.80	2.04	2.55	1.75	1.40	2.50	and Asphaltic
24" " " "	112 "	2.10	2.60	2.50	2.15	2.94	2.70	2.00	1.75	3.00	Oil value
Class A Conc. Culverts	45 c.y.	11.00	11.50	11.00	10.00	10.00	10.00	10.00	11.00	11.00	$17,820.60
" B cut & Mortar	36 c.y.	10.50	11.50	11.00	10.00	10.00	10.00	9.00	8.00	10.50	
" B paving	7180 c.y.	4.50	4.75	5.15	4.50	5.75	5.60	4.36	4.95	5.90	This work
Asphaltic Spray Asp. oil	710 bbls.	1.50	1.50	3.00	1.50	1.60	2.00	2.00	1.30	3.10	awarded to
Broken Stone Screenings	455 tons	3.10	3.00	3.50	5.00	3.75	2.50	3.50	3.50	2.50	Leigh Garney
Sand	310 c.y.	1.50	2.35	2.00	2.50	2.50	2.50	1.81	1.25	2.75	of Los Angeles
Guard rail	2744 l.ft.	.40	.45	.45	.60	.50	.50	.51	.40	.45	May 1913
Reset Monuments	134 ea.	.60	1.50	2.00	1.10	1.00	5.00	2.00	.50	3.95	

State Highway in S.	San Mateo Co.	Dist 4 Route 2.	Kirsch Imp. Co.	City Street Imp. Co.	Barber Asp. Pav. Co.	Lucas & Olney and	Western Paving			John Doyle	A. Teichert and
Items	Quantities	Estimate	San Francisco	San Francisco	San Francisco	Co. Sacramento	Co. Burlingame	Quantities	Estimate	San Jose	San Sacramento
Total Bid		$23,566.40	$19,255.05	$19,969.11	$20,470.86	$19,019.00	$34,076.70		$20,034.93	$18,071.35	$19,000.50
Excav. no classif.	2400 c.y.	.80	.45	.80	.80	.50	.90	3000 cu. yd.	.65	.50	.60
12" Corr. I. Pipe	152 l.ft.	1.20	1.30	1.80	1.60	1.40	1.65	(Note State furnishes Portland		cement - broken	stone for
18" " "	38 "	1.80	2.00	2.20	1.80	1.80	2.10	shoulders - contr. [illegible]		[illegible]	sand for [illegible] - asphaltic
Class A Concrete	60 c.y.	12.00	8.00	10.00	9.00	9.50	14.50	oil water-bind screenings - the			$[illegible] 50.)
Class B "	25 c.y.	10.00	6.00	9.00	8.00	9.50	12.75	1500 cu. yd.	3.50	2.70	3.31
Broken stone	215 c.y.	2.25	2.25	1.70	1.48	2.20	4.35	1180 tons	.72	.60	1.45
Broken & screenings								115 "	.65	.75	1.10
Asphalt mac. surface	10645 s.y.	.054	.55	.580	.640	.54	.80	(This work awarded John		Doyle May 14	1913)
Asph. bind. & place		(Note State	furnishes Steel	and Portland	Cement.)			Reset Mon. (see Asp. Bl.)	1.00	1.25	2.50
Guard rail		(This work	awarded Kirsch	IMPROVEMENT	Co. April 25	1913)		2200 l.ft.	.25	.35	.50
Reset monuments	16 ea.	1.00	2.00	2.00	3.00	2.00	3.80	15	1.00	1.00	1.00

BIDS FOR CALIFORNIA STATE HIGHWAYS.

Sausalito.—The citizens of this town have voted $100,000 in bonds to be spent in improving the streets and roads.

Los Angeles.—The board of supervisors has ordered A. J. Hill to draft an ordinance which will protect the county roads more

miles of state road leading from Washtucna toward Ritzville for $19,920.

Salt Lake City, Utah.—Utah rock asphalt will be used in paving State street. It will consist of 6 in. of concrete, with a surface of 2.5 in. of rock asphalt.

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Railways

San Francisco.—The California Railroad Commission reports the following: A decision has been rendered, on the application of common carriers, altering certain classifications of freight and readjusting minimum weights. The minimum for coke has been increased from 30,000 to 40,000 lb. Forms, tools, and materials for constructing concrete pipe are also affected. Cement rates have been reduced to points in the San Joaquin valley from Napa Junction, Davenport, Riverside, and Colton to Los Banos, Modesto, Merced, Fresno, Reedley, Exeter, Porterville, Visalia, Tulare, Bakersfield, Hanford, and Dinuba.——The value of the Sierra railway, which has 86.51 miles of road, is as follows, reproduction value, $2,697,500, and present value, $2,432,792, equal to $31,892 per mile of track.——The Stockton Terminal & Eastern Railway Co.'s property originally cost $213,747, its reproduction value is $215,918, and present value, $202,118.——The Southern Pacific Co. has filed an application asking for authority to pay discounts and commissions not to exceed 4% on the $11,000,000 equipment trust certificates recently authorized by the Commission.——The Supreme Court at San Francisco has dismissed all objections to the extension of the Geary Street Municipal Railroad to the Ferry building, and connections with the United Railroads tracks have been started.

Los Angeles.—Until the board of public utilities is provided with plans and specifications for the elevated system proposed to be built by the Pacific Electric Co. from the rear of Sixth street depot to San Pedro street, nothing will be done with the application for permission to build the structure. ——All rights-of-way having been purchased for the Upland-San Bernardino line, the Pacific Electric Co. has let a contract for the commencement of the work, the aggregate cost of which is about $2,000,000. This will connect San Bernardino with Los Angeles by a 58-mile line. This company will then have 1010 miles of track in southern California.——It is proposed to establish a union terminal station for all the railroads entering the city. Franklin D. Howell has submitted plans to the railway representatives.——The Pacific Electric Co. will connect Long Beach and Redondo with an ocean-skirting line 18 miles long, at an estimated cost of $5,400,000, when a complete right-of-way is obtained.——The city council proposes to take over the Temple-street car line when the franchise expires, and then extend it to Hollywood.

Sacramento.—The Nevada County Narrow Gauge railroad is preparing an application to the railroad commission to increase the bonded indebtedness of the road from $162,000 to $662,000 to provide funds for standard gauging the entire line from Colfax to Grass Valley; $162,000 of this money will be used for retiring the present bond issue and the balance to provide funds for the contemplated improvements. The road has recently been sold to men associated with the O. A. & E.——The Northern Electric Railroad Co. has applied to the city commission for a franchise to re-route some of its lines within the city of Sacramento. The Pacific Gas & Electric Co. has also made a similar application.

Denver, Colorado.—The Denver & Salt Lake Railroad Co. filed a notice on May 20, with the Secretary of State, relating to an increase of capital from $10,000,000 to $35,000,000.——At an election on May 20 the people of Denver voted to construct the Moffat tunnel. The proposed tunnel will commence just east of Toll, 35 miles from Denver. It will be 6.4 miles in length and its construction will cost from $4,000,000 to $4,500,000. It will shorten the road from Denver to Salt Lake City by 68 miles, as figured by the Union Pacific mileage, and 187 miles as by the Denver & Rio Grande route. It will be owned by the city and county of Denver until such a time as the Denver & Salt Lake railroad repays the entire amount of the bonds. The city retains the perpetual rights to carry water and power through the tunnel.

Lewiston, Idaho.—Citizens have subscribed $90,000 for the electric road to be built by F. L. Sturm and associates.

Salt Lake City, Utah.—The Salt Lake & Ogden Railway Co. has applied to the city commission for a franchise to connect with the lines of the Salt Lake & Utah Railway Company.

Spokane.—It is stated that work is to commence at once on the electrification of the Great Northern Railroad Co. from the Cascades to Spokane at a cost in excess of $10,000,000. It is expected that bids will be advertised soon for construction work on the big dam in the Chelan and Columbia rivers.

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Irrigation and Water Supply

San Francisco.—The city engineer has filed an appraisement of the properties of the Spring Valley Water Co. for rate-fixing purposes, as follows: The United States Circuit Court in 1903-04 fixed the value of the properties then in use at $25,074,527. Since then the Crystal Springs dam property has been increased by 214 acres, and other lands acquired. Reservoir lands are valued at $1000 and watershed areas at $100 per acre. The total value is $30,433,011, and deducting $2,313,959 for depreciation, the present value is $28,119,052.——The Railroad Commission reports the following: The San Jose Water Co. applied for authority to issue $100,000 for short-term notes.——A large number of water consumers have filed a complaint with the Commission against the Fresno Canal & Irrigation Co. The complaint states that the company has furnished inadequate service, an insufficient amount of water, and has failed to properly distribute the water.——A complaint has been lodged against the People's Water Co., Berkeley, asking for better service and larger pipes.

The Spring Valley Water Co. has ordered the construction of the Calaveras dam in Alameda county. This reservoir will cover 1200 acres of land to a depth of 300 ft., and will cost $3,000,000. The daily supply is at present 40,000,000 gal.——A report on the use of the Mokelumne river for San Francisco states that 75,000 miners inches of water are available.

Sacramento.—A. J. Rich & Co. have acquired for the Solano Irrigated Farms, Inc., nearly all the Reclamation District No. 526, north and adjoining Rio Vista, and opposite Rye island, at a cost of about $1,000,000. This land is under levees, and is rich soil. ——S. A. Cheney, United States executive officer of the California Débris Commission, was called to Washington, D. C., to attend the hearing of the Board of Engineers, on flood control of the Sacramento and San Joaquin rivers. There is $33,000,000 involved in the scheme. Active work will begin on June 15, if pending court proceedings are cleared up.

The state legislature has appropriated $100,000 for the improvement of the Sacramento river. A self-propelled snag-boat and dredge is to be used. The river from Chico landing to Red Bluff is to be rectified by a channel 4 ft. deep and 100 ft. wide.

Montague.—The survey of the canal from the Klamath river is again under way and should be completed during June.

Suisun.—The canal from Lindsay slough to a 600-acre reservoir on the Burns place, east of this town, was filled on May 8. It is 80 ft. wide, 19 ft. deep, and 10 miles long. It will supply sufficient water to irrigate 30,000 acres of Solano county lands.

Yuba City.—It is stated here that a fleet of dredges will start working in a few weeks reclaiming the 70,000 acres of Sutter basin lands recently purchased by the Armour interests.

Davis.—There is plenty of underground water here for irrigation purposes, at a depth of a trifle over 100 ft. Flows from wells are as follows: T. Schmeiser, 950 gal. per min.; J. C. Chandler, 12 in., 1800 gal.; and Speary, 1000 gal., while the Glyde, Wright, and Koontz ranches have good wells.

Nevada City.—The Pacific Gas & Electric Co. has an engineer examining the proposed irrigation project from Indian Springs and Spencerville and extending to the Bear river. This project would supply 100,000 acres.

Capay.—The Duncan dam, 1½ miles above this place, is finished. It will irrigate 40,000 acres, and the scheme cost the Yolo Water & Power Co. $150,000. A concrete dam 500 ft. long has been built, with headgates at each end, supplying a canal on the north extending to Cacheville, and one on the south carries water to Davisville. The canals have been concreted nearly 6 miles.

Los Angeles.—The Railroad Commission has fixed rates for the Conservative Realty Co., which supplies water to a district near Watts. The charges are to be 15c. per 1000 gal., and a minimum charge of $1 per month per customer.—The Riverbank irrigation system at Knight's Ferry was opened early in May. There is enough water to supply 72,000 acres. Two large reservoirs were completed on May 3 at the Whittier hills at a cost of $90,000.——The Sentinel Heights Water Co. has been formed with a capital of $2,000,000, for the purpose of supplying water to the southwestern section holdings of the Los Angeles Investment Co., and also the territory between Los Angeles and Santa Monica, as far as Inglewood.——Water will be secured from wells.——Rates fixed for water by the council were as follows: Glen-

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dale Con. Water Co., reduction from $1.50 to $1 per 800 cu. ft. supplied; Windsor Water Co., Los Angeles Co. Water Co., $1.50; Annex Water Co., $1; Eagle Rock Water Co., 75c.; Beaverwick Water Co., $1.50; Edward Stoll Water Co., $1; E. E. Hall Water Co., $1; Colegrove Water Co., $1; and Greater Los Angeles Water Co., $1.——The city has started suit against the Silver Lake Power & Irrigation Co., and the Southern Sierras Power Co., to defend its rights to power possibilities on the upper end of the aqueduct. ——On May 18 the Sand Canyon siphon of the aqueduct blew out, 25 miles south of the Harwel reservoir. The cost of reconstruction will be $18,000. This section had been suspected of weakness, and W. Mulholland, the chief engineer, had a full-pressure test made.

Klamath Falls, Oregon.—Water for irrigation was turned into the Klamath main canal on May 1.

Chandler, Arizona.—Material for the new waterworks system has been ordered. There will be 40,000 ft. of 4 to 12-in. mains, and tanks holding 50,000 and 100,000 gal. each.

Elephant Butte, New Mexico.—Concrete foundations for the big dam at this place should be up to the level of the river bed by the end of 1913. When this dam is finished there will be no shortage of water for irrigation.

Spokane, Washington.—During the month ended May 12, 900 meters had been installed in the city. The average charge for meters with a ⅝ by ¾-in. opening is $10, and for the straight ¾-in., about $14.50 per year.

Tacoma, Washington.—The Tacoma Wood Pipe Co., B. O. Skewis, manager, is getting out the order for the Hood River, Oregon, waterworks, consisting of about five miles of 14-in. and two miles of 8-in. pipe.

Miscellaneous Engineering Construction

San Francisco.—The estimated cost per mile of double track of the municipal system, according to the city engineer, including allowances for material, labor, electrical construction, car barn, cars, engineering, and incidentals, is $213,852, and the average cost per mile of single track, $106,926, while the capital investment of the United Railroads per mile of single tracks owned is, according to Bion Arnold's report, $320,800. After the Geary street road is completed from the ferries to the beach and all bills are paid there will remain a surplus of $359,358 in the Geary street bond issue. Mr. O'Shaughnessey estimates the cost of 7.1 miles of single track at $220,000, or of double track at $505,194, bringing the total expenditure for track construction to $734,633. Electric construction cost $134,790, car barn complete, including real estate and street work $301,517; cars, $341,718; engineering, plans, and construction, $29,306; extra parts and equipment, $1016; miscellaneous expenses, printing bonds, advertising, etc., $2193; and a one-half interest in the United Railroad tracks from Sansome and Market streets to the ferries, $25,000. The Jones and Jefferson street property for power-house, not now in use, cost $55,350, and there is material on hand in excess of requirements to the amount of $17,459.93, bringing the total cost of the Geary street road when completed to $1,662,983. The estimated total cost of the portion of the Geary street road in service May 1 is $1,052,413, and the interest on this sum amounts to but $130 per day. The excess of the Geary line receipts over expenditures up to the first of May totaled $37,614, which would leave a surplus over interest on the property in use since the line has been in operation of $21,525, or a surplus over interest on all bonds sold to date of $7,513.——The public works commissioners have awarded the following contracts: Construction of a rock bunker and elevator, McSheehy Bros., $1892; and general construction of academic building, Polytechnic High School, Newson, Wold & Kohn Co., $219,752.——The bridge over the Suisun straits for the Oakland, Antioch & Eastern railroad, two miles long, is now under construction. It will be 70 ft. above the water of the bay, and will cost about $1,500,000. Waddell & Harrington, of St. Louis, are in charge of bridge construction.

Eureka.—The Island Mountain tunnel, 200 miles north of San Francisco, constructed for the Northwestern Pacific Railway Co. by the Utah Construction Co. and Nels Lind & Co., is completed. It was started in May 1911, and is 4337 ft. long. The elevation of the tunnel is 549 ft., that of the hill is 1615 ft. above sea-level, and the greatest amount of earth above any point of tunnel is 1066 ft. During excavation there was taken out of the tunnel and approaches 93,000 cu. yd. of

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earth. Rock in the tunnel was found to run from shale to sandstone. Three hundred men were engaged in the undertaking, working three 8-hour shifts. The actual number of working days was 631. The average daily advance, figuring both ends of the tunnel work, was 50 in. During construction operations, 750,000 lb. of dynamite was employed, 75,000 caps, and 300,000 ft. of fuse. About 3,000,000 ft. of lumber was used. J. F. Beamen, of the railroad company, was in charge of the work. He forecasted the finish within two days, and the headings met with great accuracy.

Sacramento.—The Capitol extension plans for this city have been prepared by Wilbur F. McLure. These provide for the engineering and printing offices to be 232 by 300 ft. The city has voted $700,000 to purchase the site. The Primary and Grammar School building is to be built at Eleventh, Twelfth, U and V streets, and contracts will be let soon. It will be a fireproof structure, with 23 class and other rooms, with 1000-children capacity. The cost will be about $190,000.

Los Angeles.—There were in April of the current year, 1707 buildings of a total cost of $5,047,065 under construction in this city. During the past year, 900,000,000 ft. of lumber was received here for building and other purposes.

Globe, Arizona.—The proposed 22-mile sewage system for this place will cost about $149,638, according to the engineer, E. R. Stafford.

Spokane, Washington.—The Northern Pacific grade work, employing 250 men under Guthrie-McDougall & Co., has been stopped. M. E. Clements was the engineer in charge. ——John F. Costello has been awarded a contract for the Waikiki gravel macadam road. This is to be 6.35 miles long, and the cost is $56,650.——A 12-story steel and concrete hotel costing $1,100,000 is to be built at Spokane. Cutter & Malmgren are architects, and the Brayton Engineering Co. contractors.——For the O.-W. R. & N. Co. terminal station, Twohy Bros. secured a contract for $50,000 to clear certain obstructions and prepare footings for steel at street crossings. ——The new Whittier school is to be built by J. J. Lohrenz for $41,560. This will be of cream pressed brick, concrete interior, and Sterling stone corners.——There is a total of $33,000,000 worth of construction under way in Spokane at present.——J. C. Argall, the city purchasing agent, will call for bids on an order for 1000 to 5000 bbl. of cement. That used on the Munroe street bridge cost $2.75; then the Inland Portland Cement Co. caused a reduction to $2.25, and the last quote to the city by the International Portland Cement Co., was $1.90 per bbl. It is hoped to cut the price to $1.50. The Great Northern Railway Co. has awarded a contract for 35,000 bbl. of cement to the Inland Portland Cement Co., at about $70,000. This will be used for steel and concrete bridges, snowsheds, and tunnel linings.

Salt Lake, Utah.—The Utah Light & Power Co. is to extend its lines to Bountiful. The University of Utah Administration building is progressing well. It is 70 by 220 ft., and P. J. Moran is erecting it for $254,000. The basement is of granite, and the 'white' stone of the superstructure is all from Utah quarries.

Odgen, Utah.—A new freight depot for the D. & R. G. company is to be built at a cost of $75,000 to $100,000.

Panama-Pacific Exposition

The building and grounds committee has received bids for construction of the Palace of Manufactures and Transportation. The lowest bidder was McLaren & Peterson, who offered to do the work for $217,000. The exposition company furnishes the lumber for construction. The lowest tender for the plumbing was by J. Dougherty, at $19,630. Bids for the structural steelwork of the Exposition Auditorium were received on May 29. This will make the fifth of the large exhibit buildings to be under construction. The sewer in the main roadway of the concession district was completed on April 9. The west dock in the Fulton basin, known as the yacht harbor, is completed. The extension of the south dock to the eastward is also finished, except for the decking. The heavy framing for the north nave is completed. For the Palace of Education, 500,000 board feet of lumber has been received. In the Liberal Arts building, a huge switchboard will be erected in the centre by the Pacific Telephone & Telegraph Co. Thirty operators will be at work when the fair is opened, and there will be 2000 telephone stations distributed throughout the grounds.

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Petroleum

California.—Net production for April, according to the *California Oil World*, was as follows, stated in barrels:

	Net produc. April.	Daily Average.
San Joaquin Valley:		
Coalinga	1,507,539	50,251.30
Kern River	763,260	25,442.00
McKittrick	370,379	12,345.96
Midway	2,451,227	81,707.56
Maricopa	483,757	16,128.90
Lost Hills-Belridge	391,516	13,050.53
Total	5,967,678	
South and Coast:		
Santa Maria, Lompoc, Cat Canyon	399,442	13,314.73
Salt Lake-Sherman	216,620	7,220.96
Olinda, Brea Canyon, Puente	512,868	17,095.60
Coyotes-La Habra	245,217	8,173.90
Whittier	54,789	1,826.30
Los Angeles City	31,842	1,061.40
Newhall	8,411	280.36
Ventura County	71,470	2,715.66
Summerland	4,350	145.00
Total	1,545,018	
Grand total of state	7,512,696	250,423.20
Shipments	7,344,980	244,832.60
Losses	104,884	3,462.80
Total outgo	7,449,864	248,295.40
Surplus	62,832	2,127.80

The above figures do not take account of oil consumed in the field in the process of production. This is rapidly decreasing, owing to the increased use of electricity. Production for the first four months of the year amounted to 30,582,600 bbl., an increase of 1,961,460 bbl. over that for the same months in 1912. Consumption has increased even more rapidly, and improved marketing facilities give a better tone to business.

General Petroleum has now a rapidly increasing refining capacity, and its pipeline to the coast is in service. Gas is being delivered at Los Angeles for power purposes, but not as yet to domestic consumers. New production is coming in as rapidly as is needed.

The California Petroleum Co. has issued a statement as to resources to offset criticism from the market. It has been well received by the public.

Eastern fields, according to the *Oil City Derrick*, showed in April on completions to the amount of 60,558 bbl., which was 9471 bbl. less than in March. The Gulf Coast fields fell off 16,276 bbl., but Oklahoma, Kansas, Illinois, Pennsylvania, and Kentucky showed increases.

Miscellaneous.—Wyoming fields are coming on nicely, and Californians are becoming interested near Caspar. The Eddy county, New Mexico, field is being drilled, but final conclusions cannot yet be drawn. The Secretary of the Interior forced the closing of wells wasting over 100,000,000 cu. ft. of gas per day in Oklahoma, until the gas-sand was sealed off by the process developed at the Honolulu wells in California.

Stocks, May 1.	eld stocks.	Pipe-line.	Total.
Coalinga	412,894	2,718,852	3,131,746
Kern River	539,247	29,008,298	29,547,545
Maricopa	243,916	637,561	881,477
Midway	636,850	1,563,421	2,200,271
McKittrick	84,313	989,389	1,073,702
Belridge-Lost Hills	76,563	314,924	391,487
Santa Maria, Lompoc, Cat Canyon	311,134	482,198	793,332
Olinda, Brea Canyon, Puente	37,222	197,999	232,221
Salt Lake-Sherman	83,613	36,642	120,255
Whittier	36,944	.....	36,944
Coyotes-La Habra	36,482	.....	36,482
Ventura county	17,783	84,377	102,160
Newhall	2,186	.....	2,186
Los Angeles district	15,000	298,338	313,338
Outside of fields	.....	9,356,666	9,356,666
Totals	1,534,147	45,685,665	48,219,812

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Personal

WARREN C. EARLE has been appointed chief engineer for the State Railroad Commission.

S. A. JUDD has been appointed assistant harbor engineer for Los Angeles, California.

ERNEST ASHTON is now chemical engineer for the Lehigh Portland Cement Co., at Chicago.

WILLIAM SPROULE, president of the Southern Pacific Railroad Co., has been reëlected president of the Associated Oil Company.

Messrs. HAVILAND, DOZIER, and TIBBITS have been selected by the Richmond Municipal Water District to make surveys for Richmond, California.

F. S. BURROUGHS, chief engineer for the Washington State Public Service Commission, has reported on the present affairs of the Spokane Gas & Fuel Company.

M. ROY THOMPSON, county engineer of Pierce county, Washington is preparing the plans for grading down Meridian street in South Puyallup from a 16 to a 9% grade.

SYLVESTER Q. CANNON has been appointed city engineer at Salt Lake to succeed DAVID H. BLOSSOM, resigned. R. E. COLLIER will probably succeed Mr. Cannon as water engineer.

A. L. TROWBRIDGE, head field engineer of the Pacific Gas & Electric Co., California, is in Nevada county, investigating an irrigation system for 100,000 acres of foothill land.

D. L. HUNTINGDON, president of the Washington Water Power Co., has been in San Francisco, attending a meeting of the executive committee of the Pacific Coast Electric Railway Association.

C. E. GRUNSKY, G. McM. ROSS, and J. L. CRAIG, have been appointed members of the general educational committee of the National Drainage Congress which opened at Washington, D. C., May 22.

M. O. LEIGHTON has left the United States Geological Survey to join the staff of J. G. White & Co. He is succeeded as chief hydrographer by N. C. GROVER, at one time with J. G. White & Co., but since chief engineer of the Land Classification Board.

The following changes have been made in the San Francisco-Oakland Terminal Railways (Key Route) under the scheme of reorganizing the F. M. Smith interests: E. A. HERON has resigned as president, W. A. BISSELL takes his place, and J. K. MOFFIT succeeds the latter as vice-president of the company.

O. S. BOWEN, resident engineer at Spokane, Washington, for the Great Northern railway, has moved to Seattle. His territory will now include lines in British Columbia, Washington, Idaho, and part of Montana.

THOMAS W. WALSH, chief dispatcher and assistant superintendent of the Oregon-Washington Railroad & Navigation Co. at Spokane, has been promoted to be superintendent of a newly made division with headquarters at La Grande, Oregon.

S. H. MCCRORY, T. F. HUNT, FRANK ADAMS, WILLIAM N. HALL, SIDNEY W. COOPER, W. A. KELLY, W. G. SLOAN, and R. A. HART recently inspected the proposed district, which is to be reclaimed by drainage in the Salt Lake valley, between the Jordan river and Great Salt Lake, Utah.

Society Meetings

THE PACIFIC NORTHWEST SOCIETY OF ENGINEERS will probably hold its annual convention August 1 and 2.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS held its spring meeting at Baltimore, Maryland, on May 20 to 23.

THE UTAH IRRIGATION AND DRAINAGE CONGRESS has been organized at Salt Lake, by the Commercial Club. The meeting was attended by 60 delegates representing all sections of the state.

THE UTAH SOCIETY OF ENGINEERS held its regular monthly meeting on May 16. L. M. Bailey, general manager of the Portland Cement Co. of Utah, read a paper on 'The Manufacture and Uses of Portland Cement.' A discussion followed by Willard Day, R. K. Kletting, G. M. Bacon, and A. B. Villadsen. On the following day the Society visited the Salt Lake plant of the company mentioned.

STANDARD OIL CO. (California) has issued bulletin No. 5, 'Scientific Road Construction,' with many illustrations of testing equipment and showing the stages of modern permanent road construction. This 32-page booklet sent upon request.

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